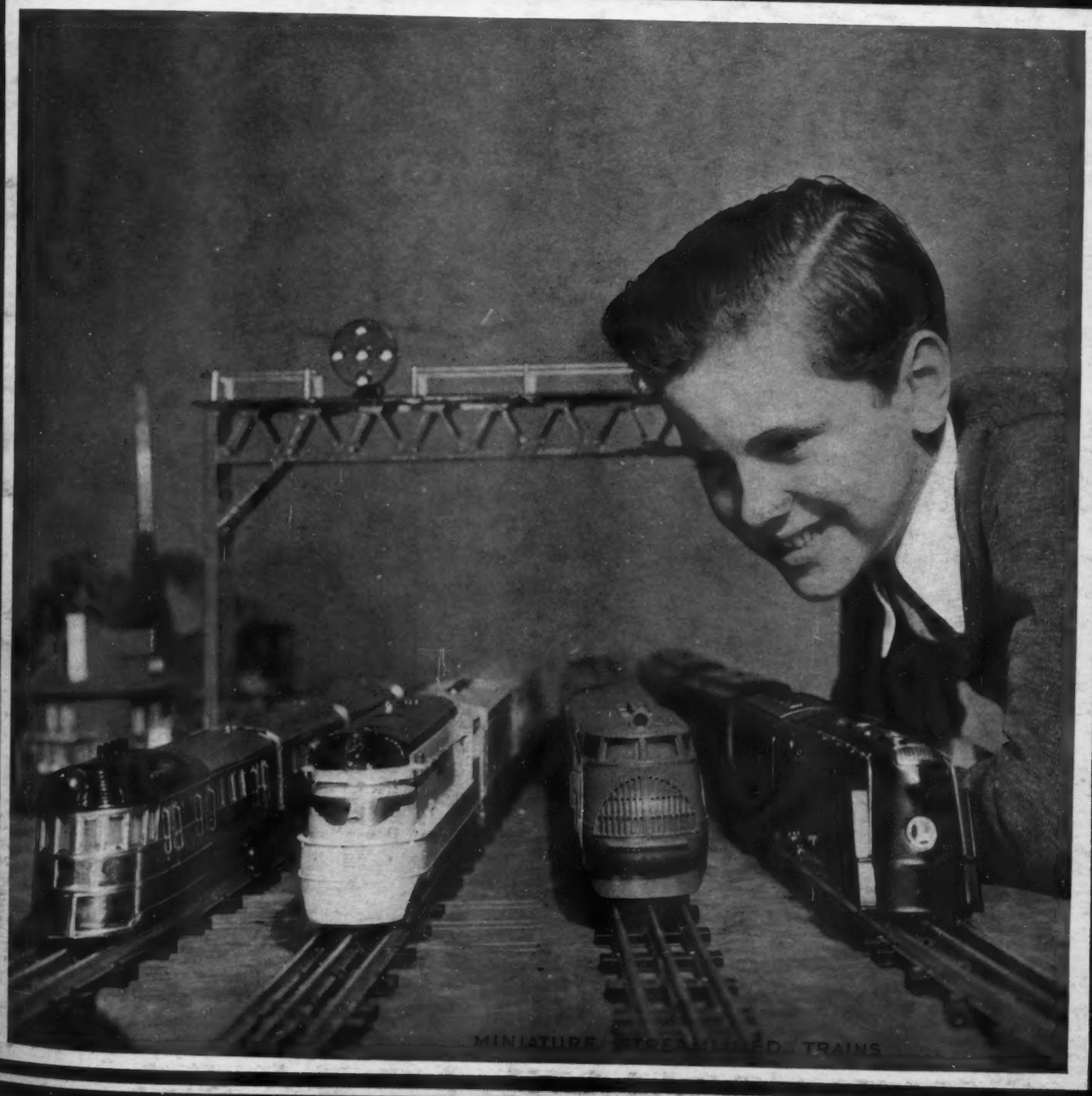
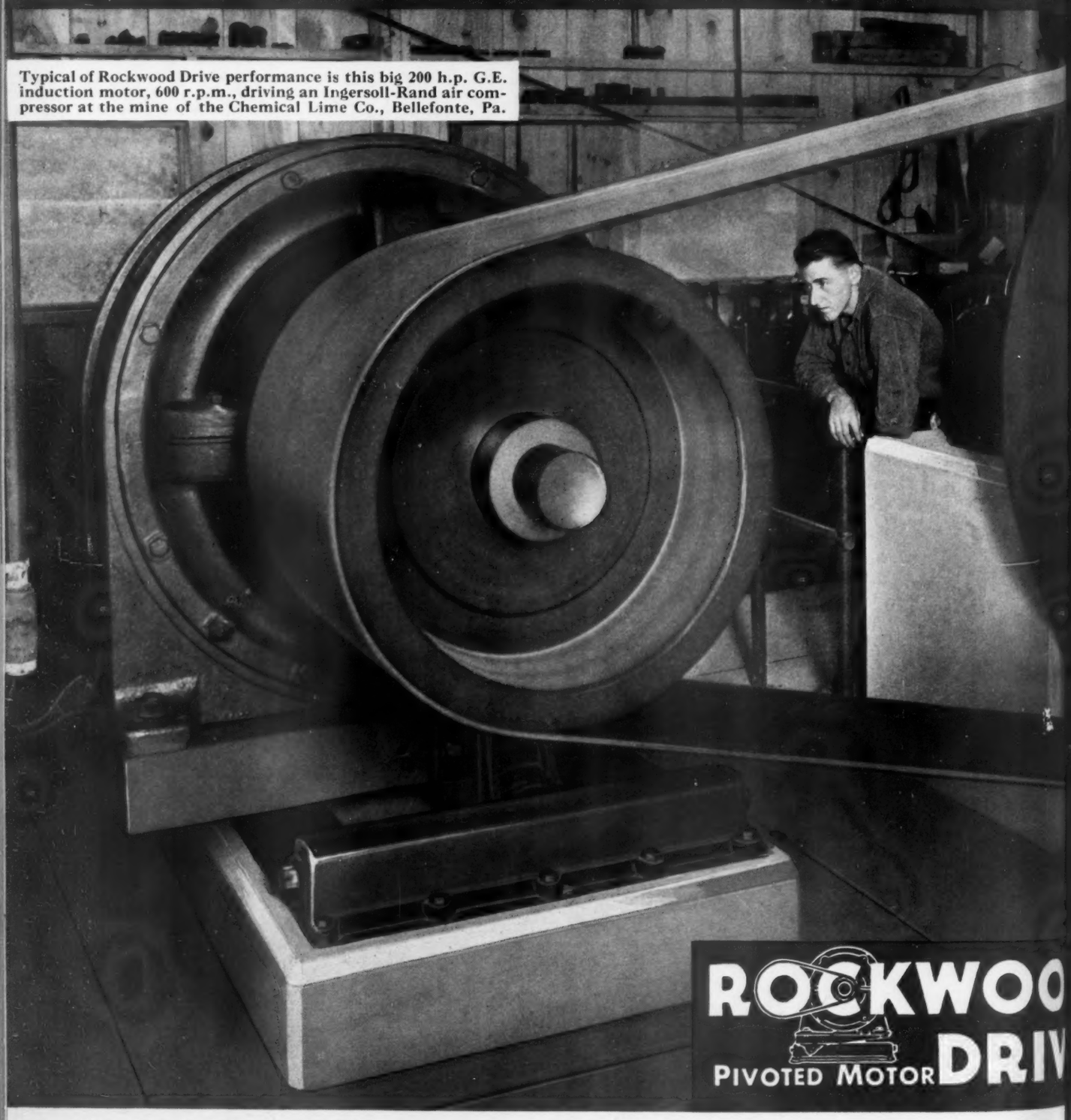
Compressed Air Magazine

Vol. 42, No. 3 London - New York - Paris March, 1937



MINIATURE STREAMLINED TRAINS

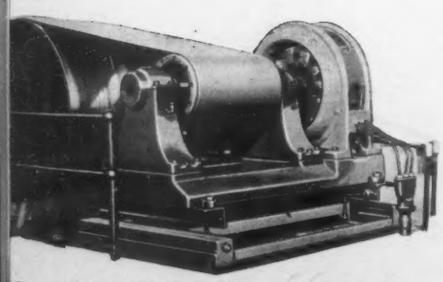
Typical Rockwood Drive Performanc



Typical of Rockwood Drive performance is this big 200 h.p. G.E. induction motor, 600 r.p.m., driving an Ingersoll-Rand air compressor at the mine of the Chemical Lime Co., Bellefonte, Pa.

ROCKWOO
PIVOTED MOTOR DRIV

"FOR THE FIRST TIME A COMPRESSOR BELT DRIVE THAT IS TRULY SATISFACTORY"



One of two 400 h. p. Rockwood Drives at City of Dubuque, Iowa, water works.

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ANNUAL INDEX

COMPRESSED AIR MAGAZINE publishes an index to each volume, but does not make general distribution of it for the reason that comparatively few readers bind each year's issues. A copy of the 1936 index will be sent all applicants upon request.

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THE diesel engine was conceived in Europe, where gasoline costs much more than it does here. American technologists were quick to recognize its possibilities; but interest here centered on heavy-duty, slow-moving diesels because smaller units weighed far more than gasoline engines of equal power. It was not many years, however, until improvements and refinements forecast the time when small diesels and semidiesels would compete with gasoline engines in some services even in this country. State governments undoubtedly stimulated diesel research by imposing higher and higher gasoline taxes. American industry, today, is distinctly diesel-minded, and American diesel manufacturers are leading factors in world markets. Diesel-engined trucks are here, and diesel-driven automobiles and airplanes are perhaps just around the corner. The article, *The Diesel Engine—Past and Present*, traces the evolution of this type of machine in a manner that should interest the general reader as well as the engineer.

•

THE lyrical saga of Casey Jones, the redoubtable locomotive driver, is a part of American folklore, along with *Casey at the Bat*. All males seem to possess the railroading instinct. Thanks to miniature trains, they can indulge this passion without leaving their firesides. Foremost among makers of small trains is the Lionel Corporation. Almost as fascinating as the trains themselves is the fact that they evolve essentially from rolls of sheet steel, and that the annual output is so great as to require several million pounds of this material. Compressed air performs important services in the plant operations. The story of the Lionel Corporation and of its manufacturing methods is told in this issue.

•

MANY parts of mechanical things are cast in dies, with the aid of power applied either pneumatically or hydraulically. The list of die-cast products is continually increasing, owing largely to the development of suitable alloys for the purpose. Zinc is the commonest basic material, although lead, aluminum, brass, magnesium, and others are of importance. Herbert Chase, who wrote the article on die casting in this issue, is an authority on the technology of the process.

Compressed Air Magazine

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Volume 42 **MARCH, 1937** **Number 3**

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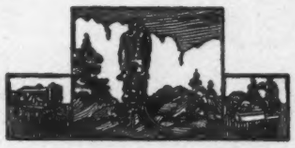

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A monthly publication devoted to the many fields of endeavor in which compressed air serves useful purposes. Founded in 1896.

Published by Compressed Air Magazine Company. G. W. MORRISON, president; R. A. LUNDELL, vice-president; F. E. KUTZ, secretary-treasurer.

Business, editorial, and publication offices, Phillipsburg, N. J.

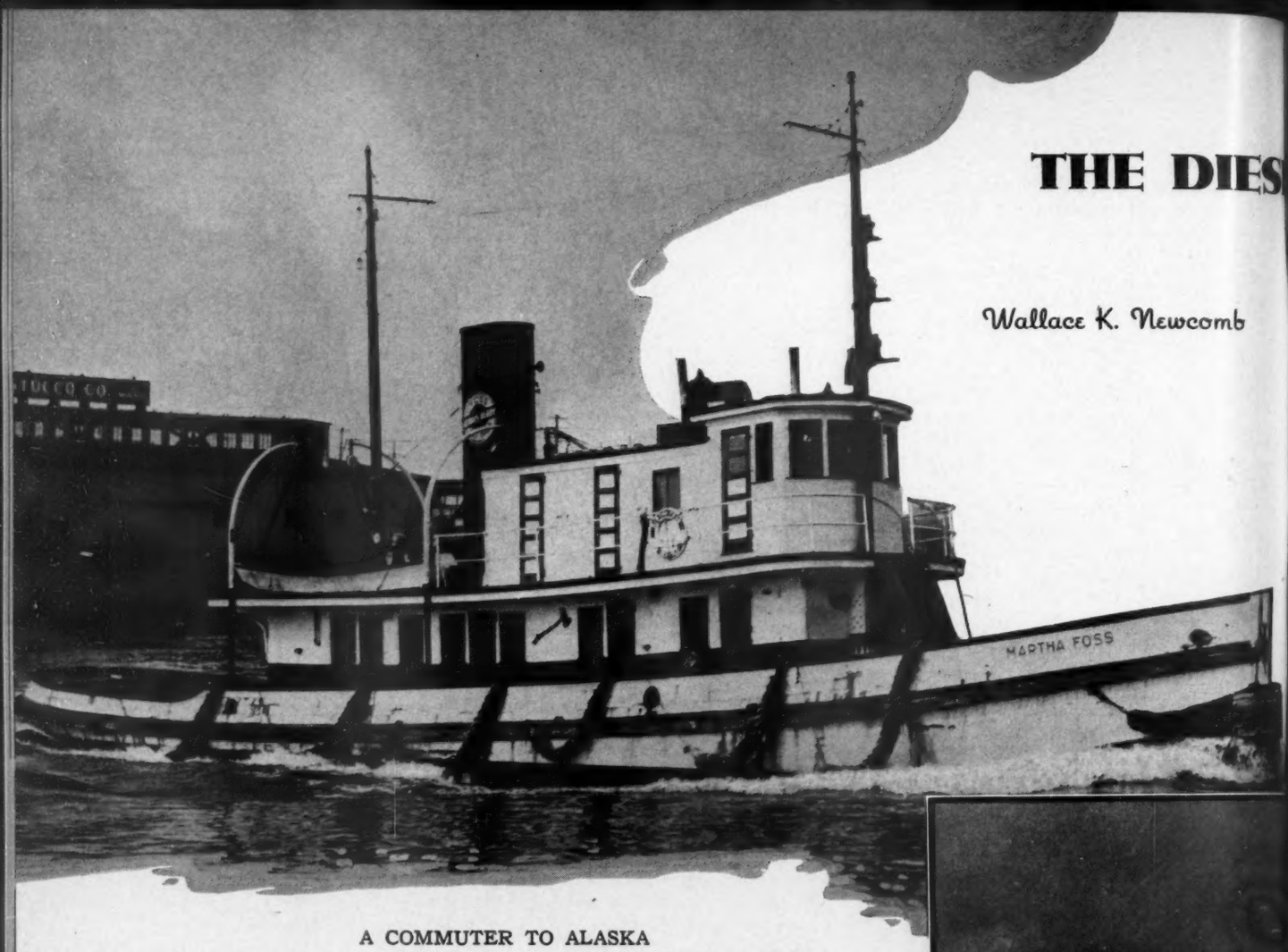
Advertising Office, 11 Broadway, New York, N. Y.

Annual subscription price: domestic, $3.00; foreign, $3.50. Single copies, 35 cents.

Compressed Air Magazine is on file in many libraries and is indexed in Industrial Arts Index.

THE DIES NG

Wallace K. Newcomb



A COMMUTER TO ALASKA

During the past six years, this diesel-engined tugboat has completed ninety 2,000-mile trips between Seattle, Wash., and Alaska, each time with a 1,000-ton scow in tow. It plies between those points both winter and summer. The boat is owned by the Foss Company, Inc., of Seattle, and went into service in 1927. It is powered by an Ingersoll-Rand 240-hp., direct-reversible diesel engine.

The growth of the diesel-engine industry in the past few years has been so phenomenal as to command widespread attention. Not only have diesel engines increased in industrial and marine applications but they are now also found on rails, on rubber tires, and in the air. With diesel-powered trucks and buses on the highways, and diesel trains flashing through the countryside, the diesel engine has reached a status of more than passing interest to everybody. This article, which was originally presented as a paper before a meeting of the American Society of Mechanical Engineers, explains the principles of the diesel engine and traces its evolution to the present stage.

WE THINK of the diesel as a heavy-fuel-oil-burning engine; but strange as it may seem, the first one was designed to operate on coal dust. I say "designed," because it blew up and became a total wreck as soon as it was started. This engine was the invention of Dr. Rudolf Diesel, a German engineer, who developed the original theory of the high-compression internal-combustion engine in which the fuel was ignited by the heat of compression. Other engines were built that actually ran and developed power. They differed in many respects from the first one, and used liquid fuel instead of coal dust. A commercial single-cylinder engine of 25 hp. was produced in Germany in 1897, just five years after the date of the original diesel patent. A year later the first diesel engine was built in America.

In the beginning, progress was slow; but then, with a gradually increasing market for an engine that would burn heavy petroleum, the advance of the diesel became rapid, especially in Europe. Incentive to develop it was the existence of low-cost petroleum fuels. A world-wide demand had sprung up for kerosene for lighting and heating purposes. Kerosene was obtained by the fractional distillation of crude petroleum, and the process yielded by-products of gasoline and naphtha, as well as distillates having boiling points higher than kerosene. We all know how the low cost of gasoline stimulated the development of the gasoline engine; and, likewise, the low cost of the heavier petroleum fractions was largely responsible for the diesel. From the very first the diesel engine proved to be an efficient machine—a factor that became as important in its progress as that of fuel cost.

Our present-day conception of the diesel is an engine in which the fuel is ignited by the heat of compression rather than by an electric spark or external heating device. It is an engine in which the fuel is introduced directly into the cylinder without previous carburation. To insure easy starting in cold weather, a compression pressure of 400 to 500 pounds per square inch is used, and the temperature at the end of compression is in the order of 900° to 1,000°F. The fuel is introduced in the form

NGINE - Past and Present

of a spray into this incandescent air when the piston is near dead center, and it ignites and burns completely in an incredibly short time. The heat of combustion results in expansion of the air, the energy of which acts on the piston during the power stroke. The diesel engines now built differ in many respects from their predecessors, but still have much in common with them.

In the older diesel engines the fuel was injected with a blast of high-pressure air that pulverized or atomized it and distributed it throughout the cylinder where it mixed with the air. In this manner the fuel was brought in contact with the oxygen necessary to support combustion. Now we are able to accomplish this without the aid of an air blast, and can dispense with the cumbersome compressor which was generally driven from an extra throw on the crankshaft.

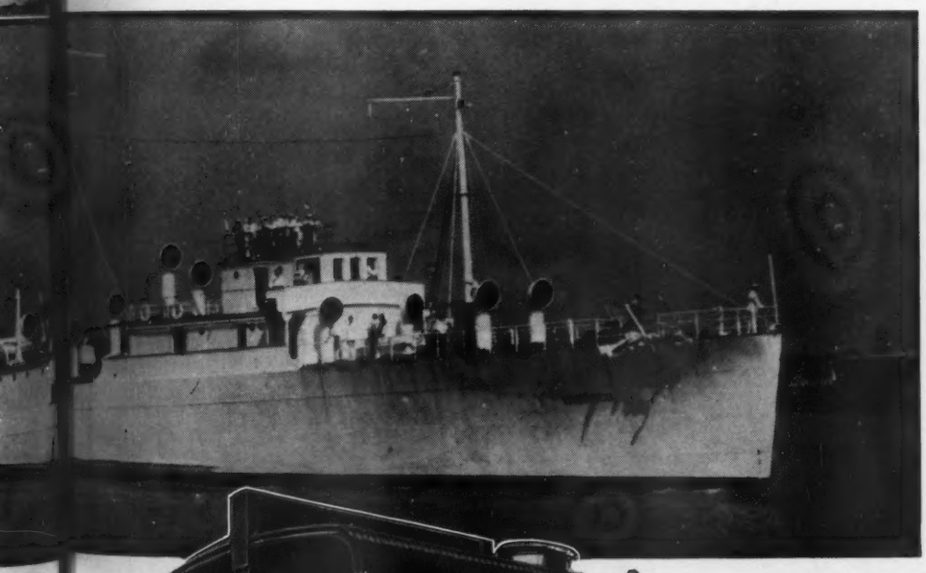
In the modern diesel the fuel is sprayed into the cylinder under high pressure. The fuel issues from a nozzle, not unlike a garden sprinkler, and may be directed in many fine streams into the compressed air so that it is evenly distributed. Or, if preferred, the air in the cylinder or combustion space may be whirled or set in motion in such a way that it sweeps through the fuel spray and supplies the air for combustion. Sometimes very high fuel pressures of 5,000 pounds per square inch or more are required to effect fuel injection, but the art of building suitable fuel-injection pumps has advanced to such a degree that it presents no problem.

The diesel engine is inherently a high-pressure machine with maximum firing pressures in the cylinder exceeding, in some cases, 750 pounds per square inch. It is necessarily heavier and more expensive than a gas or gasoline engine of equivalent power, where the firing pressures seldom are more than 350 pounds per square inch. The early diesels were especially heavy and costly; and it is not surprising to find that attempts were made in the course of the development to build lighter and cheaper engines that could burn the same fuels. These engines had lower compression pressures than the diesels—150 pounds per square inch—and were correspondingly lighter. Starting was not possible with such low compression pressures without some auxiliary heating device such as a hot spot or an electric heating coil. In some of the engines a part of the cylinder head was left uncooled and had to be heated with a blowtorch before starting. The fuel spray was arranged to impinge on the hot spot, and thus ignition was secured. When running under load, the heat of combustion was sufficient to keep the hot spot at the required temperature.

However, these engines left much to be desired. Operating on low compression, they were less efficient than the diesel. Also, the fuel sprayed against the hot spot formed

SPEEDING BANANAS TO MARKET

The ship pictured below was once a destroyer in the U. S. Navy. It is one of four such vessels that were converted into banana carriers and equipped with Ingersoll-Rand diesel engines. This form of propulsion assures maximum room for cargo and operating reliability at low cost. The boats average more than 15 knots on the trip from Honduras to New York.



FIRST DIESEL LOCOMOTIVE

The first successful diesel engine for a locomotive in America was built by Ingersoll-Rand Company in 1923, and the first locomotive was put in service by the Central Railroad of New Jersey in October, 1925 (below). It is still in use at the Bronx Terminal Market in New York City. Since that pioneer made its appearance, 118 locomotives, powered by I-R engines, have been sold. All that have so far been placed in service are still operating, and their average length of service to date is more than six years.

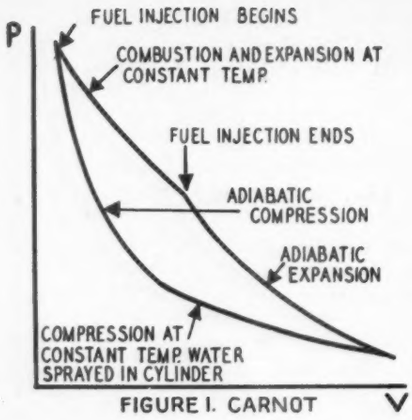


FIGURE 1. CARNOT

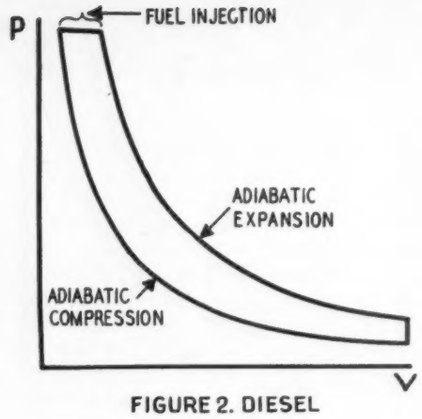


FIGURE 2. DIESEL

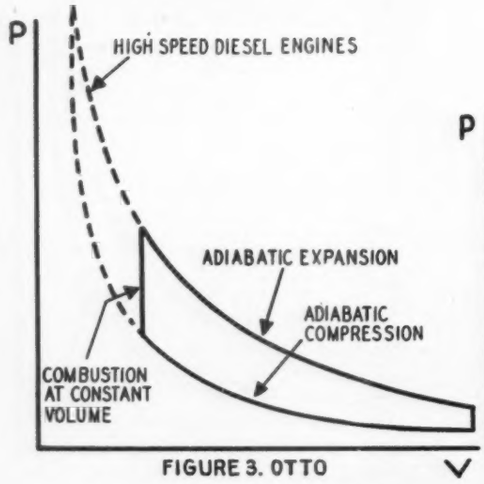


FIGURE 3. OTTO

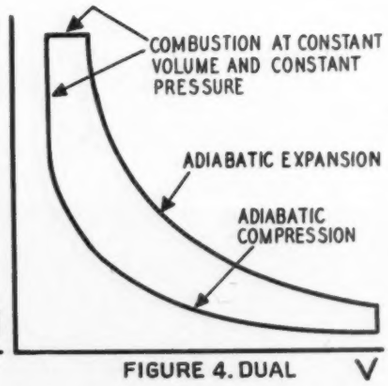


FIGURE 4. DUAL

VARIOUS OPERATING CYCLES

Rudolf Diesel's first engine was intended to operate on the Carnot cycle, but the wrecking of his initial unit prevented him from proving that it would show the high efficiencies that were theoretically possible with such a design. Following his death, his associates built another engine that differed somewhat from the original. It produced an indicator card such as is shown in Figure 2, which is now universally known as the Diesel cycle. Gas and gasoline engines operate on the Otto cycle (Figure 3). Hot-bulb engines, that were developed along with the early diesels, produced an indicator card similar to Figure 4. The cycle is like both the Otto and Diesel cycles, the ignition lag of the fuel being responsible for this peculiar condition.

carbon deposits which were troublesome. Starting was difficult, and the engines were not flexible. When the load was removed, the hot spot would cool off and the engine miss fire and knock.

Twenty years ago these hot-bulb, low-compression engines reached their highest development and were popular; and the trouble they gave was not all in vain because it was found that by increasing the compression pressure to 330 pounds per square inch the engine would start cold without the aid of any heating device. These medium-compression oil engines were very efficient, equaling in this respect the existing air-injection diesels. The modern diesel is a direct descendant of the original diesel and the medium-compression oil engine.

There has been a tendency during the last decade to call all compression-ignition engines diesels in spite of the fact that the modern high-speed diesel, and many slower-speed engines as well, do not operate on the diesel cycle. Reference to the accompanying theoretical pressure-volume diagrams of the different cycles of operation will help to explain this paradox.

The original diesel engine was designed to operate on the Carnot cycle, (Figure 1), which begins with isothermal compression of the air, water being sprayed into the cylinder during the early part of the stroke to maintain constant temperature. Then the water is shut off and compression continued as adiabatic compression, with neither cooling nor heating, until a temperature is reached sufficient to ignite the fuel, which is introduced at the beginning of the expansion stroke at such a rate as to maintain constant-temperature combustion and expansion. At some point in the expansion or power stroke the fuel injection is cut off and the remaining expansion is adiabatic. No cooling is provided other than that derived from the water spray. Doctor Diesel's first engine was intended to operate in this manner, and he expected to obtain the very high efficiencies which were theoretically possible; but the wrecking of the machine prevented him from proving it.

However, his associates and backers had the vision to see the merit of the high-compression engine, and another was built, although it differed considerably from the original. Liquid fuel was burned, and the cylinder was water-jacketed like in other internal-combustion engines. The water spray for producing constant-temperature compression was eliminated. Figure 2 shows the theoretical indicator card of the cycle of operation that was finally obtained. The entire compression was adiabatic; and at the end of the stroke the liquid fuel was sprayed into the cylinder at such a rate as to maintain combustion at constant pressure. The fuel was cut off and the stroke continued with adiabatic expansion. The sequence described is universally known as the Diesel cycle, and actual indicator cards of slow-speed, air-injection engines closely approximate it.

Let us now refer to Figure 3, illustrating the Otto cycle on which gas and gasoline engines operate. It consists of adiabatic compression, combustion at constant volume, and adiabatic expansion. In gas and gasoline engines operating on this cycle the fuel and air are generally mixed outside of the cylinder in the carburetor or mixing valve. The explosive mixture is drawn into the cylinder during the suction stroke, compressed, and ignited by an electric spark.

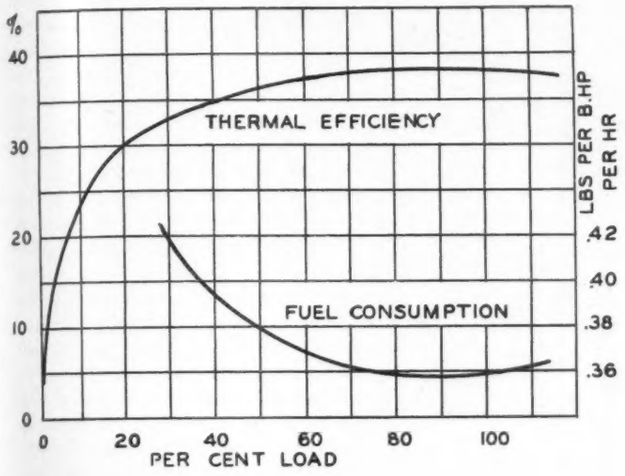
It is most important that the compression pressure should not exceed a certain maximum value depending on the thermal stability of the fuel, for if it does, then pre-ignition and detonation—which are detrimental—will occur. In modern gasoline automobile engines the compression ratio is from 5 to 1 to 6 to 1, which corresponds to a pressure at the end of compression of 100 to 140 pounds per square inch.

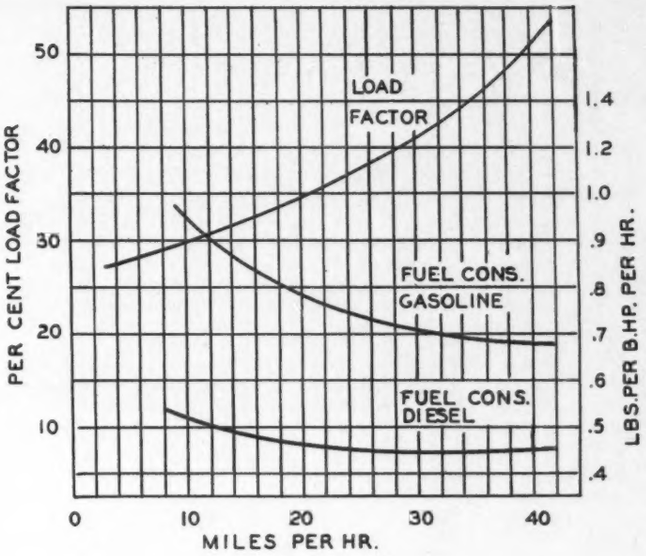
The hot-bulb engines, which paralleled the development of the diesel for the first twenty years, produced indicator cards which were difficult to classify. After adiabatic compression of the air charge, fuel was injected and combustion was apt to be rather erratic—sometimes fast and sometimes slow, according to the temperature of the hot spot and other service conditions. When operating nicely it is similar to Figure 4. However, when the compression pressure was raised to 350 pounds per square inch, the cycle took a more definite form. Part of the combustion took place at constant volume and the remainder at constant pressure. The cycle is like both the Otto and Diesel, the ignition lag of the fuel being responsible for this peculiar condition.

When the fuel is sprayed into the cylinder it does not ignite immediately, but there is a delay during which the fuel is heated and partly vaporized. This process may take less than 1/2,000 of a second; but during that time one-third of the fuel to be injected is already in the cylinder. One or

DIESEL EFFICIENCY

Below are plotted the fuel consumption and thermal efficiency that were obtained in a test of a 750-hp., 6-cylinder diesel engine making 225 rpm. Smaller and faster operating units are practically as efficient, and larger engines show to even better advantage. Whether large or small, diesel engines are much more efficient than steam units.





TRUCK CURVES

This diagram compares the fuel consumption of gasoline- and diesel-powered trucks. The use of diesel engines in trucks and buses is expanding rapidly; and in Europe diesel-powered taxicabs are making their appearance.

two droplets of oil which have been heated sufficiently burst into flames, and other droplets ignite, only a few at first and then more in rapid succession until the cylinder looks as though filled with myriads of flying rockets. Before another 1/4,000 of a second has elapsed, the entire mass is aflame. This very rapid combustion causes a rapid pressure rise, which is indicated by the almost vertical line on the indicator card.

At this point in the cycle only about one-half of the fuel is injected, and the remainder, ignited by the intense heat now in the cylinder, burns as it issues from the spray nozzle and as the piston begins to move down, maintaining constant-pressure combustion in the cylinder. This constant-pressure burning may continue for another 1/2,000 of a second, by which time fuel injection will be cut off and combustion finished. Because of this ignition delay, we usually find, in high-speed engines, that most of the fuel is in the cylinder before ignition occurs and that burning is very rapid, resulting in an indicator card such as Figure 3, which is similar to the Otto cycle with combustion taking place at constant volume.

The diesel engine owes its position not only to the availability of low-cost fuels but also to its inherently high efficiency. Modern diesels operate with 40 per cent thermal efficiency; and when exhaust-heat recovery is practicable, the over-all efficiency may exceed 50 per cent. The diesel is more efficient than any other prime mover.

The diesel engine has become a real competitor of the gasoline engine for marine, industrial, and automotive use. Its fuel is cheaper than gasoline, and it is more efficient over a wider range of loads. The diesel is usually heavier because the cylinder pressures are higher and it must be more sturdily built; but, even so, it is rapidly replacing the gasoline engine in heavy tractors and motor boats, and its use in motor trucks and buses is increasing. Its greater weight does not prevent it from being installed in aircraft, because its higher efficiency reduces the quantity of fuel required. This is particularly well illustrated by the zeppelin *Hindenburg*, which is equipped with four 16-cylinder 1,100-hp. diesel engines. Its fuel consumption is 1,000 pounds an hour less than it would be if gasoline engines were used; and after a few hours of flying, the saving offsets the additional weight of the engines. Moreover, the fire hazard is greatly reduced.

By casually examining the combustion systems of diesel engines, one is confronted with many different designs with seemingly different principles. There are precombustion-chamber engines, and single-spray, opposed-spray, multi-spray, central-injection, side-injection, and turbulence types. But certain distinct principles will be recognized, and permit dividing such engines into three general classes:

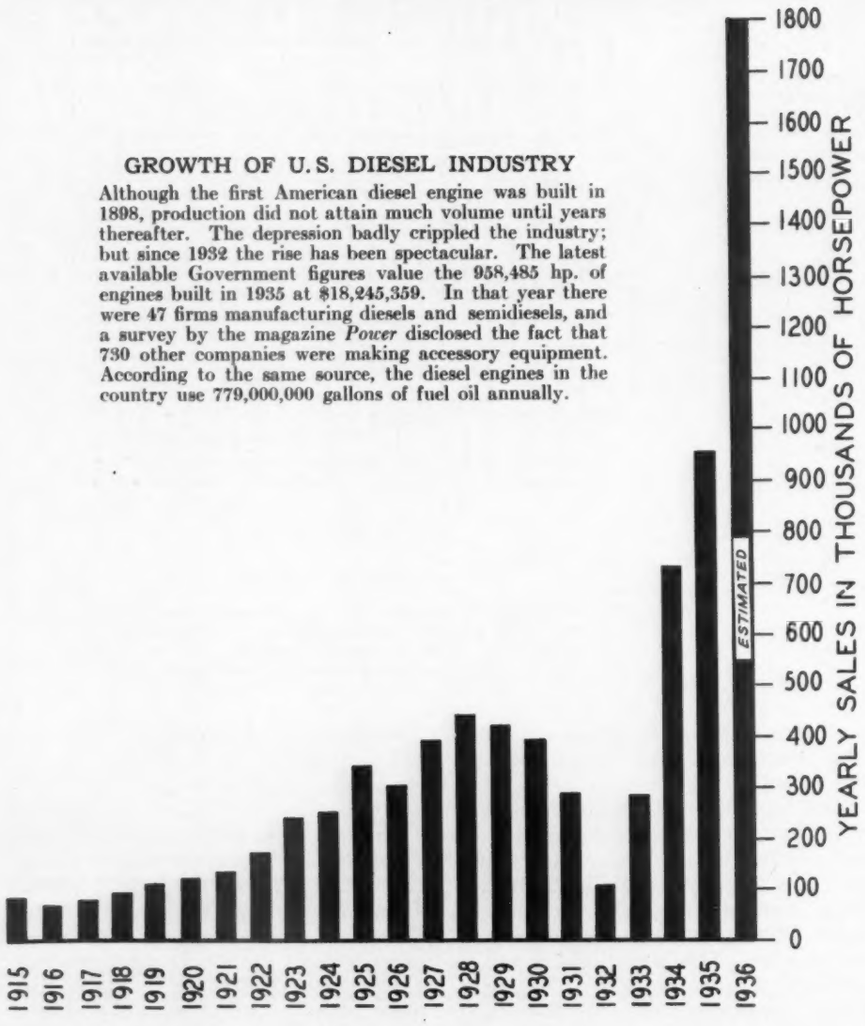
1—Engines in which the air is more or less quiescent and in which the fuel spray is carefully aimed or directed into the combustion chamber. Here several sprays are usually required in order that the fuel may reach all the air. In this system the fuel must find the air.

2—Engines with precombustion chambers.

3—Engines which depend upon turbulence or upon an orderly movement of air past the fuel spray. To derive the greatest advantage from this system, the air should sweep past the spray at a velocity corresponding to the fuel injection so that just sufficient air will be supplied to support combustion. In this system the air seeks the fuel.

The first engine to work on the fuel-seek-the-air principle was developed twenty years ago by Vickers for British submarines. No attempt was made to secure turbulence, and a centrally located injector sprayed the fuel in many fine outwardly directed jets into the combustion space formed by a depression in the top of the piston. The engines that originally used this system were comparatively low-speed machines; but efforts have been made to adapt it to engines operating at fairly high speeds—up to 1,000 rpm. However, the system is limited to moderate bores, and is better suited for slower speeds because of the large number of small holes in the fuel injector. An engine running at 300 rpm. may require an injector having five holes of 0.015-inch diameter, and an engine at 600 rpm. seven holes of 0.012-inch diameter, and so on.

The precombustion system, on the other hand, is more suitable for small high-speed, automotive-type engines. In this case, an auxiliary chamber is provided which communicates with the main combustion chamber through several small holes. Fuel is sprayed into the auxiliary chamber and proceeds to burn, with the result that the pressure rises and the partly consumed fuel is blown at very high velocity through the holes into the main section of the combustion chamber. There it continues to burn as it finds additional air, which is necessary to complete combustion. Engines operating on this system have an indicator card much like air-injection engines—that is, it follows the constant-pressure cycle. The rapid pressure rise,



GROWTH OF U.S. DIESEL INDUSTRY

Although the first American diesel engine was built in 1898, production did not attain much volume until years thereafter. The depression badly crippled the industry; but since 1932 the rise has been spectacular. The latest available Government figures value the 958,485 hp. of engines built in 1935 at $18,245,359. In that year there were 47 firms manufacturing diesels and semidiesels, and a survey by the magazine *Power* disclosed the fact that 730 other companies were making accessory equipment. According to the same source, the diesel engines in the country use 779,000,000 gallons of fuel oil annually.

which is usually a feature of high-speed diesels, is suppressed in the auxiliary chamber.

The turbulence type of combustion chamber is more adaptable and can be used in connection with high- and low-speed engines and with large as well as small units. In the Junkers opposed-piston, 2-cycle engine, the air is given a whirling motion during its passage through tangentially directed inlet ports and rotates about the axis of the cylinder throughout the compression stroke and the combustion period. The air blows at right angles through the fuel spray, supplying oxygen for combustion and carrying off burned gases. One or more spray nozzles are employed, depending on the size and speed of the machine. The Ricardo "Comet" engine operates on this same general principle; but the air is made to whirl by passing it at high velocity through a tangentially directed port upon entering the combustion chamber.

The Price combustion chamber, used in Ingersoll-Rand medium- and low-speed engines, combines the first and third systems. Here the fuel spray is directed into the combustion chamber by two opposed spray nozzles, each having a single orifice, and the air movement or turbulence is effected by forcing the air that is between the piston and the lower face of the combustion chamber through a constricted passage into the combustion chamber.

The recently developed Ingersoll-Rand combustion system on high-speed engines has two opposed nozzles, each with a single orifice like the Price but arranged to spray the fuel into a depression in the top of the piston. The air goes through a tangentially directed nozzle-shaped intake passage, which gives it a rapid, whirling motion about the axis of the cylinder and causes it to race around in the depression like a whirlwind and to make 4,500 rpm., or half a revolution during the fuel-injection period.

The fuel is injected at a uniform rate, and fresh air is supplied to the spray to support combustion, the burned gases being carried away as they are formed. This system is very simple and gives exceptional performance. It can be placed in the third class, in which the air seeks the fuel. It may be of interest to know that both the Price and the Ingersoll-Rand whirlwind systems are American developments: the others that were mentioned originated in England and in Germany.

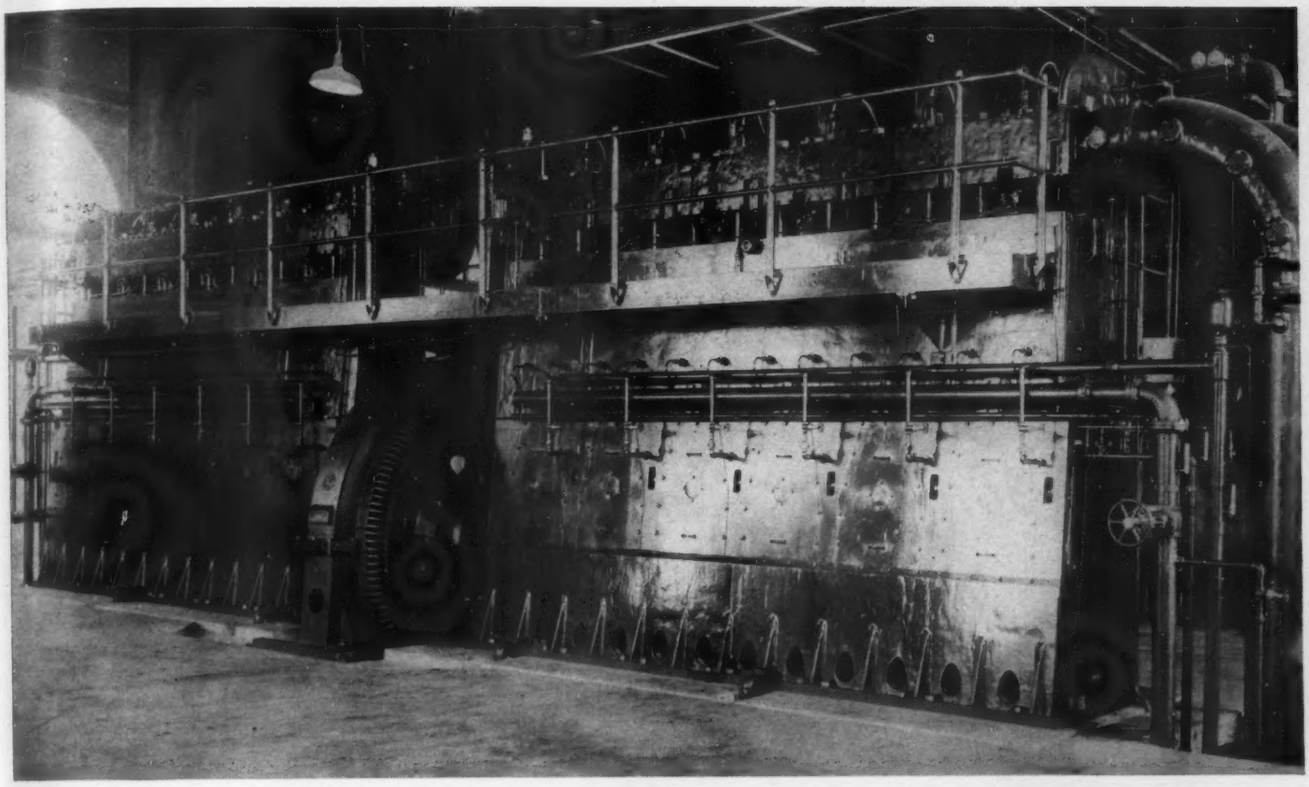
During the past decade the status of the diesel engine has changed considerably. Looking backward ten or fifteen years, we find that most diesels were used for pumping oil through pipe lines and in central stations. Some units were in operation in ice plants, mines, quarries, tugboats, and ships; but for pipe-line-pumping-station service the diesel enjoyed a preference that was almost exclusive. That was logical, because the engine obtained its fuel from the pipe line and used only half as much as steam equipment would have required. At this time, also, the diesel locomotive made its appearance.

But rapid strides have been made since then, and today there are available diesels from 5 to 20,000 bhp. operating at speeds up to 3,000 rpm. For shifting and transfer service the diesel locomotive is recognized to be superior to steam; and diesels are appearing on main lines and in high-speed streamlined trains. Diesel tractors are common, trucks and buses are becoming more numerous, and in Europe diesel-powered taxicabs are being introduced. Fast ocean liners and 16-knot diesel freighters are taking business away from steamers that are slower and yet more expensive to run—as a matter of fact, there are whole fleets of diesel-engined ships. Diesel locomotives are probably destined to supplant steam, just as the automobile has taken the place of the horse and buggy. They differ radically from the iron horse, and may seem unusual at first appearance; but already they are a familiar sight in some railroad yards.

It is unwise to predict the future course of a development that has been as rapid as that of the diesel engine. I recall a college professor, an instructor in diesel-engine design, who taught that the diesel was essentially a low-speed, large-capacity machine and that small, high-speed engines were a physical impossibility. The accurate metering, injecting, and burning of such small quantities of fuel, he thought, could not be successfully accomplished. And that was true at the time.

Still further progress is to be expected. Perhaps no radical changes; but a gradual and persistent increase in speeds and mean effective pressures. During the past few years the power output of diesels has been increased as much as 50 per cent by operating at higher speeds and at greater mean effective pressures, and the weight and cost of the engines have been reduced. Another 30 to 50 per cent increase in rating is possible by means of supercharging. Supercharging, of course, is not new. It has been used on gasoline engines of high output for many years; but the modern high-speed diesel is especially responsive to it.

Earlier it was mentioned that the compression ratio of a gasoline engine is limited by preignition and detonation, for which reason supercharging is not carried to a very high degree without cooling the air charge during its passage from the supercharger to the engine. The diesel has no



INDUSTRIAL DIESEL INSTALLATION

This engine and six others made by Ingersoll-Rand Company furnish 7,500 hp. for operating a large cement mill in Texas. The unit shown is a 12-cylinder machine that develops 2,000 hp. when making 240 rpm.

such limitations, and supercharging may be employed to such an extent as to increase the engine power by half. Such diesels compare very favorably with gasoline engines on the basis of weight; and the over-all efficiency of the supercharged engine is not appreciably less than that of one not supercharged.

Of course, diesel engines are built to operate on both the 2-cycle and 4-cycle principles. The early diesels were all 4-cycle machines, and not until ten years ago did the 2-cycle principle become a serious competitor. About half of all large diesels now being constructed operate on the 2-cycle principle. Some 2-cycles have been built with cylinder bores less than 10 inches, and while they have given a very good account of themselves, yet it is too soon to predict how far they will invade what hitherto has been considered the exclusive field of the 4-cycle. The main advantage of these high-speed 2-cycle engines is light weight; but the supercharged 4-cycle engine is its equal in this respect.

To sum up, we may say that the diesel engine fills a definite need for an efficient, self-contained, and automatic form of motive power. The industry is still in its infancy; and, as development continues, the engine will be assigned to new tasks.

OIL-ENGINE-DRIVEN PORTABLE COMPRESSOR

Diesel and semidiesel engines with a total capacity of 160,000 hp. went into contractors' equipment in 1936, so it is estimated. One place where such engines have proved reliable and economical in this particular field is in portable air compressors. The unit pictured is driven by a Waukesha Hesselman oil engine having spark-plug ignition. In these engines, the compression and maximum pressures are only about one-third of those developed in a true diesel, and, consequently, a Hesselman is little heavier than a gasoline engine of equivalent horsepower.

Lionel Trains

C. H. Vivian

IT IS perhaps a safe guess that nine out of every ten men determined at some time during their boyhood days that they were going to be locomotive engineers when they grew up. And boys of this generation do not differ much from their fathers. That may explain the fascination miniature trains have for nearly all males, young and old, rich and poor. It is such a strong and persistent impulse that officials of the Lionel Corporation estimate that from 15 to 25 per cent of the train sets it sells go to adults. The figures are based on reports from its salesmen. But there is no telling how many additional trains are bought ostensibly for junior members of the family when, as a matter of fact, the breadwinners themselves harbor a passion for doing a little indoor railroading.

Offhand one would conclude that a business that has such an impelling human desire serving as an unpaid salesman would be sure to flourish, and that is correct. Sales figures are not divulged; but it suffices to mention that a week after inventory was taken last January, the Lionel Corporation put 550 persons to work in its factory at Irvington, N. J., to start making trains and related articles to supply the demand that will laze along through spring, summer, and autumn and then suddenly burst into racing speed at Christmastime.

About May or June, when Lionel salesmen begin making their rounds interviewing retail storekeepers in regard to their Christmas needs, the force at Irvington will be enlarged, and it will continue to increase until, during the final three months of the year, it will reach 1,200. For the miniature-train business is essentially a

COMPARING TRAINS

The boy is comparing a Lionel streamliner with the Union Pacific's *City of Portland*, after which it is modeled. The miniature train is one forty-fifth the size of the real one. The demand for streamliners, though they are still popular, is decreasing.

LIONEL EXHIBIT

A window display, in the Lionel offices in New York City, that illustrates one of the many realistic backgrounds that can be created for miniature railroads. In the same office there is an operating exhibit that includes specimens of each Lionel product. Some store displays abroad are even more elaborate than they are in this country.

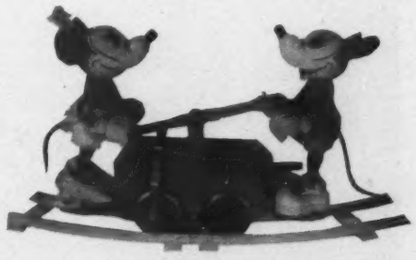
yuletide proposition, and a large percentage of the year's output is disposed of within a few days. Dealers are naturally loathe to stock up much in advance, so they carry only a few sets during eleven months of the year. In August or September they place their Christmas orders for delivery in November. If preholiday business is good, they may reorder in December, even up to a few days preceding Christmas, and they want immediate delivery. So the factory at Irvington works throughout the year. It sends the products to a warehouse, in another part of Irvington, and there they are assembled into sets and boxed for shipment. During the final three months of the year, the warehouse crew is likewise augmented, and when the Christmas rush gets into full swing, the beaverish bustle continues for 16, 20, and even 24 hours a day.

The Lionel Corporation is the world's largest maker of miniature trains. According to the best obtainable estimate, it supplies about 75 per cent of the domestic demand for these products. In addition, it is rapidly becoming an important factor in world markets, which heretofore have been dominated by British and German manufacturers. Lionel trains are now sold in 83 countries. The distributors are principally dealers in electrical appliances and radios. Such stores are natural outlets, as they have the technical personnel and the facilities for servicing sets; and, besides, the product fits in well with their established lines, particularly as a railroad exhibit in full operation serves to draw prospective customers.

One great difficulty had to be overcome before Lionel trains could make much headway in European countries. Means had to be devised by which the different voltages at which electric current is distributed could be transformed to that required to run the trains. In the United States it is usually 110; and in England and throughout most of the British Empire, 220. In some other countries there is little standardization. In Switzerland, for example, current is distributed at 120, 125, 150, and 220 volts, depending upon the locality. Transformers that were designed for use in this country obviously would

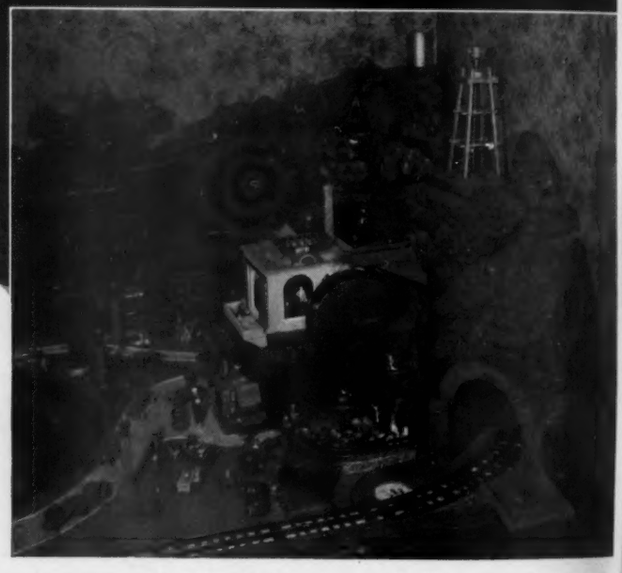
ON THE COVER

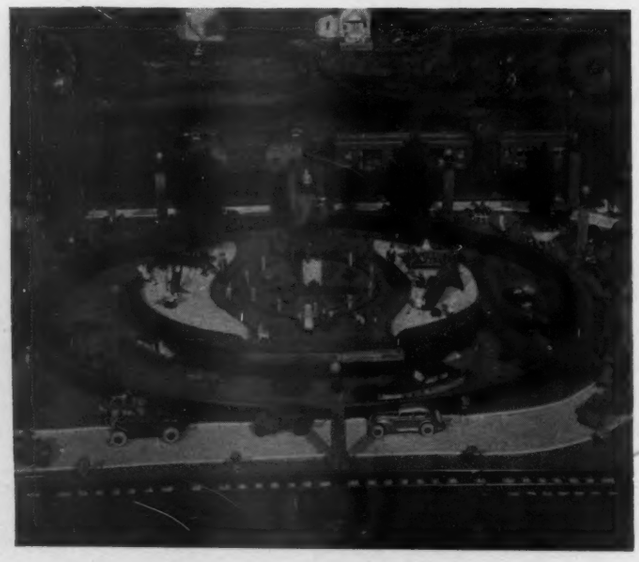
The lucky youth shown gazing fondly upon Lionel models of four crack American trains is Billy Butterfield. He is the grandson of Bob Butterfield, senior engineer of the New York Central Railroad, who operates the *Twentieth Century Limited* between Harmon and Albany, N. Y. From left to right, the trains shown are: the *Flying Yankee* of the Boston & Maine Railroad; the *Hiawatha* of the Chicago, Milwaukee, St. Paul & Pacific Railroad; the *City of Portland* of the Union Pacific Railroad; and the *Commodore Vanderbilt* of the New York Central Railroad.



A POPULAR TOY

The Mickey Mouse hand car is a favorite with children. It operates on a track, and is supplied power by a clockwork motor. A similar Lionel product features two other well-known Walt Disney characters, Donald Duck and Pluto the pup.





A CHRISTMAS-TREE "PUTZ"

In many parts of the world it is the custom at Christmastime to set the tree upon a platform that is elaborately decorated with a miscellany of miniature models of objects, animals, and persons. Such displays are particularly popular in those sections of Pennsylvania that are populated by the descendants of German settlers and are known as *Putz*, which means adornment. The platform pictured here was built by Richard T. Jackson, COMPRESSED AIR MAGAZINE photographer, in his home at Easton, Pa. The top view shows the entire *Putz*, and the others are close-ups of various parts of it. Water, circulated by a hidden pump, is lifted to the small tank in the upper right-hand corner and flows continuously to feed cascades and to run the miniature water wheel. Just beyond the wheel is a power house containing an engine that is operated by an electric motor. The boats in the waterway (bottom, left) are drawn around by magnets placed beneath the floor. Here and there are several hundred human and animal figures, nearly all of which are molded of metal. The mountains in the background are made of metal foil, arranged over wood falsework and then spray painted in natural colors. Close inspection of the pictures will reveal lights at different points, including an airplane beacon on the tower at the right-hand edge of the set. As is usually the case, a miniature train system occupies an important position in the display.

work in only a few other parts of the world. Consequently, numerous complications arose in attempting not only to make suitable transformers for each section but also to send to each the one that would meet its requirements. Mix-ups were unavoidable. The problem was solved by developing a universal transformer that would operate through a voltage range of from 90 to 250 and with current at from 40 to 133 cycles.

It is significant that the urge to play with trains is worldwide. Some countries buy more Lionel sets than do others, chiefly because they have more money to spend; but the interest in them seems to be as great in one place as in another. In the matter of arranging operating displays, foreign stores sometimes surpass those in America—one of the most elaborate Lionel exhibits in the world being in a department store in Cape Town, South Africa.

In the United States, this desire for railroading finds expression in more expensive ways than merely buying and running made-up trains of the Lionel type. There are wealthy men—and the number is fairly large—who carry their hobby to the point of installing on their estates small-gauge tracks over which they operate diminutive steam trains powerful enough to haul people. The locomotives are literally handmade by skilled mechanics; and several American experts make a comfortable living by turning them out to order.

In other instances, where men singly do not possess the funds necessary for this sort of thing, groups are formed, and long hours are spent in collectively constructing and operating tiny railroad systems. One of these is the New York Society of Model Engineers, which maintains club and workrooms in one of the large office buildings near the heart of Manhattan. Set up there is an electric railroad system so extensive that it is equipped with telephone connections between the various control switchboards.

RAW MATERIAL

Sheet steel of various thicknesses comes into the plant in rolls, each weighing from 1,500 to 2,000 pounds. As received, the strips are 26 inches wide, and are then cut into the different widths required for making essential parts of the finished products.

However, the typical American man who goes in for miniature railroads contents himself with a store set—the beginning of a modest transportation system in his cellar or garret. He can purchase a complete Lionel train set at any price between $8 and $70, and for additional equipment he can spend almost any amount. One New Jersey man has a layout in his basement that represents an expenditure of $1,000 and that includes more than 70 Lionel locomotives.

But comparatively few persons have enough room in their homes to keep such systems set up. The custom is to assemble them at Christmastime, to operate them on all possible occasions for a few weeks, and then to put them away until the following year. When December comes around again, the hobby is taken up with renewed enthusiasm; and, like as not, the catalogue is perused and an order placed for more equipment or accessories to make the system a little more elaborate.

In some parts of the country, the toy railroad is a still more conspicuous feature of that festive season. There, it is the practice to mount the Christmas tree on a base or platform that is decorated to represent an outdoor scene. It may be a snow-capped mountain region, with miniature streams cascading down the slopes and operating a grist mill or a hydroelectric plant. Somewhere may be an ice-covered lake, dotted with small molded-metal figures in skating outfits, or, again, the base of the tree may be encircled by a canal on which navigate boats drawn by magnets. Here and there will be buildings of various types, and perhaps an airport with flashing beacons. Trees and shrubs lend reality to this make-believe world, as well as figures of human beings and of domestic animals in natural settings. Platforms of this kind grow from year to year, and some of them are intricately wrought works of art. But, whether simple or complex, they are almost certain to include a miniature railroad with a depot and from one to twenty other structures and appurtenances.

Where youthful members of the household are the sole or chief railroaders, sets may of course come out of storage several times in the course of a year; and where a boy is fortunate enough to have exclusive use of a part of the cellar or of the attic, permanent displays are often arranged

WINDING TRANSFORMERS

Here deft fingers, sharp eyes, and ingenious machinery jointly perform a speedy operation. Wires from twelve spools are wound simultaneously on to the rapidly rotating core between the operator's hands. When finished, it is cut into twelve windings.

SPRAY-PAINTING

Giving tank-car bodies an aluminum finish with the aid of compressed air. There are six of these spray booths, and two more are being provided.

that rival in completeness and ingenuity anything that adults can create.

By way of stimulating juvenile interest, the Lionel Corporation has for several years sponsored an organization called the Lionel Engineers Club. For a small sum, paid annually, each member receives a magazine devoted to stories and articles dealing with railroading and containing suggestions for features that will make the miniature railroad systems more attractive. Usually, specific directions, supplemented by plans, are included. Recently, the scope of the magazine has been broadened to appeal as well to builders of model airplanes and boats, and the publication has been placed on news stands.

Perusal of a few back numbers of this periodical brings to light some interesting facts that probably even few railroadmen know. It is set forth, for example, that the original miniature electric train antedated the first full-sized electric train by 50 years. It was exhibited at a meeting of scientists in Troy, N. Y., on October 14, 1835, by Thomas Davenport, a blacksmith. It consisted of a car operated by a crude motor that received current from a battery mounted on top of it. It traveled on a circular track 3 feet in diameter. Davenport argued that real trains could be run in the same manner; but no one paid much attention to him. Afterward, though he exhibited his model in many other places, he could not obtain the financial support necessary to prove his idea, and died without ever having seen an electric train. One reason for the apathy shown by the scientific men was that they were at that time engrossed with the possibility of discovering a perpetual-motion machine, and had ears for little else.

From the same source was obtained the little-known information that the idea of streamlined trains is more than 75 years old. Its originator was the Rev. Samuel R. Cathrop, who, besides being minister of the Boston Unitarian Church, was a scientist, inventor, and a Harvard University athletic coach. Observing the Harvard racing shells cleaving the water, he began to wonder why land vehicles were all flat-nosed. On a drawing board in his attic he laid out a train that he called the *Air Resister*, and received a patent on it in August, 1865. He endeavored to have some railroad company build one and try it out, but without success.

The Reverend Cathrop's creation closely resembled our streamlined trains of today. Sheathing came down over the wheels of the locomotive and coaches, and accordion hoods between the cars articulated the entire train. The only projection was the smokestack of the locomotive. The same article discloses the fact that the Baltimore & Ohio Railroad built a streamlined train in 1910; but the savings in running expenses were not so great as its designers had promised, and the scheme was abandoned.

The recent trend towards streamlining has, incidentally, been reflected in Lionel trains. Some of the nation's best-known crack streamliners have been copied—the similarity extending even to the matter of color. A model of one of the Union Pacific's new trains has been produced on a scale of 1 to 45; and it is interesting to note that one of them was operated by the New York Society of Model Engineers on a banked track at a speed of 180 scale-miles per hour. This figure was arrived at by multiplying the actual speed by 45. Lionel officials state that streamlined models were in great demand when they first came out. Now their popularity is waning somewhat, and the conventional "iron horse" of bygone years is again the favorite.

The name Lionel comes from that of the company's founder, Joshua Lionel Cowen. In his late teens, Mr. Cowen was employed by Henner & Anderson, the firm which made the first dry-cell batteries in the United States. He seems to have been partial to small things even then, for to him is accredited the application of tiny electric bulbs to such objects as surgical instruments and flashlights. In 1900, Mr. Cowen, then twenty years old, formed the Lionel Corporation and began to manufacture miniature train sets consisting of a locomotive, coach, and caboose. Motive power was supplied by an electric motor that drew current from dry batteries. These sets sold for $6 each.

Five years after the company was launched, a student of naval engineering, Mario Caruso, went to work for it. He displayed such talents that he rose, through various technical and executive positions, to be part owner. Today Mr. Cowen is president and Mr. Caruso treasurer, and together they are the principal owners and directing heads of the concern. Four years ago, Lionel purchased the Ives Company, originally a prominent builder of clockwork trains and later a successful manufacturer of electrical units.

The present Lionel line embraces just about everything that has to do with miniature railroads, and some other products in addition. Mechanical hand-car sets that run on rails with clockwork power and

CONTRIBUTING OPERATIONS

Superstructures and running gear of Lionel trains are made almost entirely of sheet steel and of zinc-alloy die castings. The operator at the left is tapping screw holes in die castings to facilitate assembly. The motor is the heart of the train and must therefore be built with great care. Just below is shown the end of the motor-assembly line where finished units are given a running test and thorough inspection. The young lady pictured at the bottom evidently enjoys her job of wrapping miniature tank cars as they reach the end of the assembly line.

that feature Walt Disney's popular characters—Mickey Mouse, Donald Duck, and Pluto, the pup—have been large sellers in recent years. The figures are molded from a plastic material with a wood-pulp base, and are painted, partly by hand, to closely resemble the screen characters they represent.

Last year the company brought out an airplane that was an immediate success. The body is made of treated cloth and the propeller of soft rubber. The motor is located in the base of a metal tower, which is connected to the plane by a small metal tube within which is a flexible driving element similar to that used for operating automobile speedometers. The power thus transmitted spins the propeller at a sufficient rate to fly the plane at a good speed. It is remotely controlled by means of two levers, one of which regulates the power and the other causes the plane to ascend, descend, and to perform loops and other maneuvers.

Included in the line of trains are not only small replicas of practically every type of locomotive and car in general use but also of most every accessory structure that goes to make up a railroad system. Besides passenger and freight stations and other buildings, there are tunnels, bridges, landscaping for rights of way, a special rubber sound-deadening compound for ballasting track, and numerous other objects and devices calculated to add interest and realism to the systems. Auxiliary motors can be rigged up to operate coal and grain elevators, turntables, windmills, loading cranes, and other mechanical features. Track comes in several gauges to accommodate equipment of different sizes, and both tubular and solid rails can be had. There are complete signal systems of the semaphore

type, and switches that can be remotely controlled by electricity.

One of the specialties recently provided for locomotives is a whistle that can be sounded by remote control. It consists of an electric motor that drives what amounts to a small turbo-blower. The rush of air created is directed through two passageways in a zinc-alloy casting that houses the assembly, thus giving a 2-tone blast that closely approximates the whistle of a real locomotive.

The Irvington factory is laid out like an automobile or tractor plant. As the material flows along it undergoes the multiplicity of operations required to form the essential parts of trains and related products, which then converge upon assembly lines. In the principal assembly department, a belt runs at right angles to seven others, delivering materials to them either as needed or to stock shelves from which they can be taken later and placed on the proper belts. This system is very efficient and flexible, and permits using the various assembly lines for the production of any one of a wide variety of articles.

In another department there are two additional assembly lines. These normally serve for the purpose of building freight trains, but can be adapted for making up other products, as desired. Where individual parts, such as motors, must be assembled before their incorporation in finished units, there are still more belts which move the work from one operator to another. In order to speed up production, it is necessary only to increase the number of workers stationed along the assembly lines.

The principal raw materials for Lionel train sets and related products are sheet steel and zinc alloy, of which the former is the more important. There was a time when most miniature trains were rather flimsy affairs, made up of thin metal sections and incapable of withstanding much abuse; and a certain amount of these lower-priced toys are still on the market. For many years, however, Lionel has built only the better-grade units and, size for size, its trains are probably as sturdy structurally as the real ones after which they are patterned.

The sheet steel varies in thickness from 30 to 16 gauge, which is equivalent to a range of from 0.012 inch to 0.062 inch. It is cold rolled at the mills, and is delivered to the factory in rolls about 3 feet in diameter and weighing from 1,500 to 2,000 pounds each. All strips are 26 inches wide when received, and the first operation in the factory is to cut them into the required widths. With that as a beginning, they are subjected to the various stamping and forming processes during which some individual rolls are transformed into hundreds of thousands of tiny parts. Very few of the pieces attain their final shapes in one operation, and a great many of them have to be handled from three to six or more times. Virtually all these intermediate steps are performed mechanically.

The preliminary stamping is done by automatic presses, some of which form as many as 300 pieces a minute. The sheet steel, in coils, is fed to the machines, where it is stamped out by dies and then blown aside by compressed air to make way for the advancing strips. Some of them perform a sequence of operations, the strip in each case moving from one position to the next until it is completed. Most of the final forming is done by presses which are each attended by an operator who places the pieces, one by one, in the proper position between the dies. A foot treadle controls the power that causes the upper die to descend. Nearly all these machines, of which there are more than 100 in one room, are provided with air jets to remove the finished work.

The range of articles produced from sheet steel is surprising. It includes not only the wheels and superstructures of cars but likewise the tubular rails and ties that go to make up the tracks on which they run. The quantities in which some of these pieces are turned out also is much greater than the casual visitor would suspect. For example, there is one press that produces 100,000 ties for a certain gauge of track every working day in the year, while a second one makes 60,000 for another gauge. Every shop order placed for sheet-steel wheels calls for 2,000,000 units.

All wheels and boiler ends of locomotives, the undercarriages of certain of them, and most of the superstructures of those that

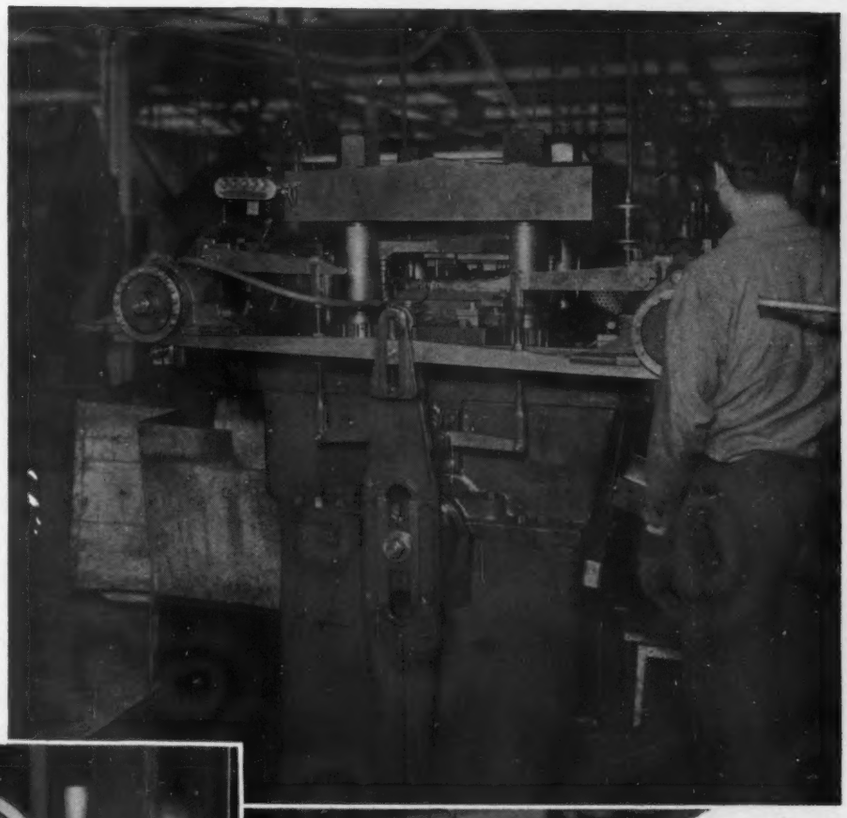
ASSEMBLING HOUSES

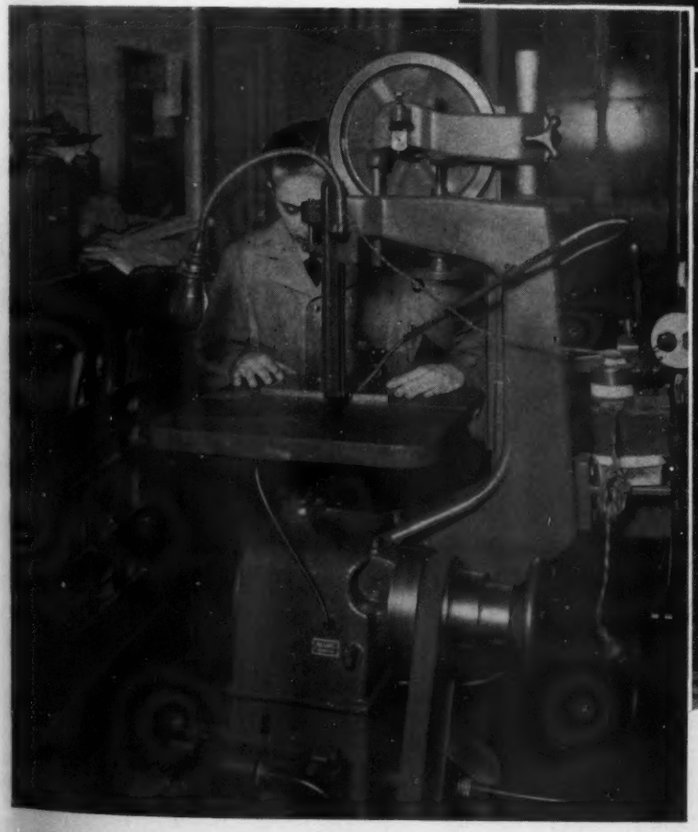
These structures are typical of the many that are produced to embellish miniature railroad systems. They are made of sheet steel throughout. Each house consists of 41 pieces, which are formed and painted prior to assembling.

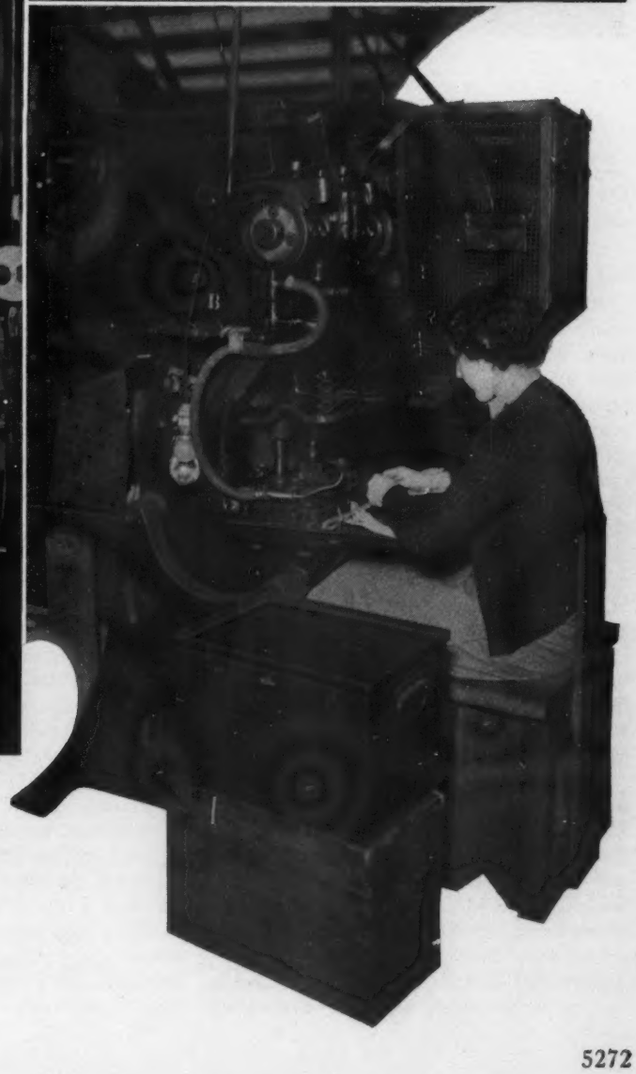
are incorporated in streamlined trains, are zinc-alloy die castings. Driving gears and other small pieces are of the same material. Several kinds of die-casting machines are in use. One is of the goose-neck type, in which the operating pressure of 400 pounds per square inch is secured by compressed air acting directly on the molten metal. In the case of the others, compressed air is applied to a piston, giving a casting pressure of 1,200 pounds per square inch.

Compressed air for the die-casting department is furnished by an Ingersoll-Rand Class ER-2 compressor that discharges at 400 pounds pressure. Air at 90 to 100 pounds for the metal-stamping presses, for spray-painting, and for miscellaneous purposes, is supplied by an Ingersoll-Rand Class ES-1 machine of 426 cfm. piston displacement. A smaller Class ER-1 unit, that carried the plant load for many years, now serves as a standby. For some services, such as spray-painting, the air has to be free from moisture, and to that end it is led through a Type PL aftercooler that is interposed between the compressor discharge and the air receiver.

One of the noticeable features of Lionel

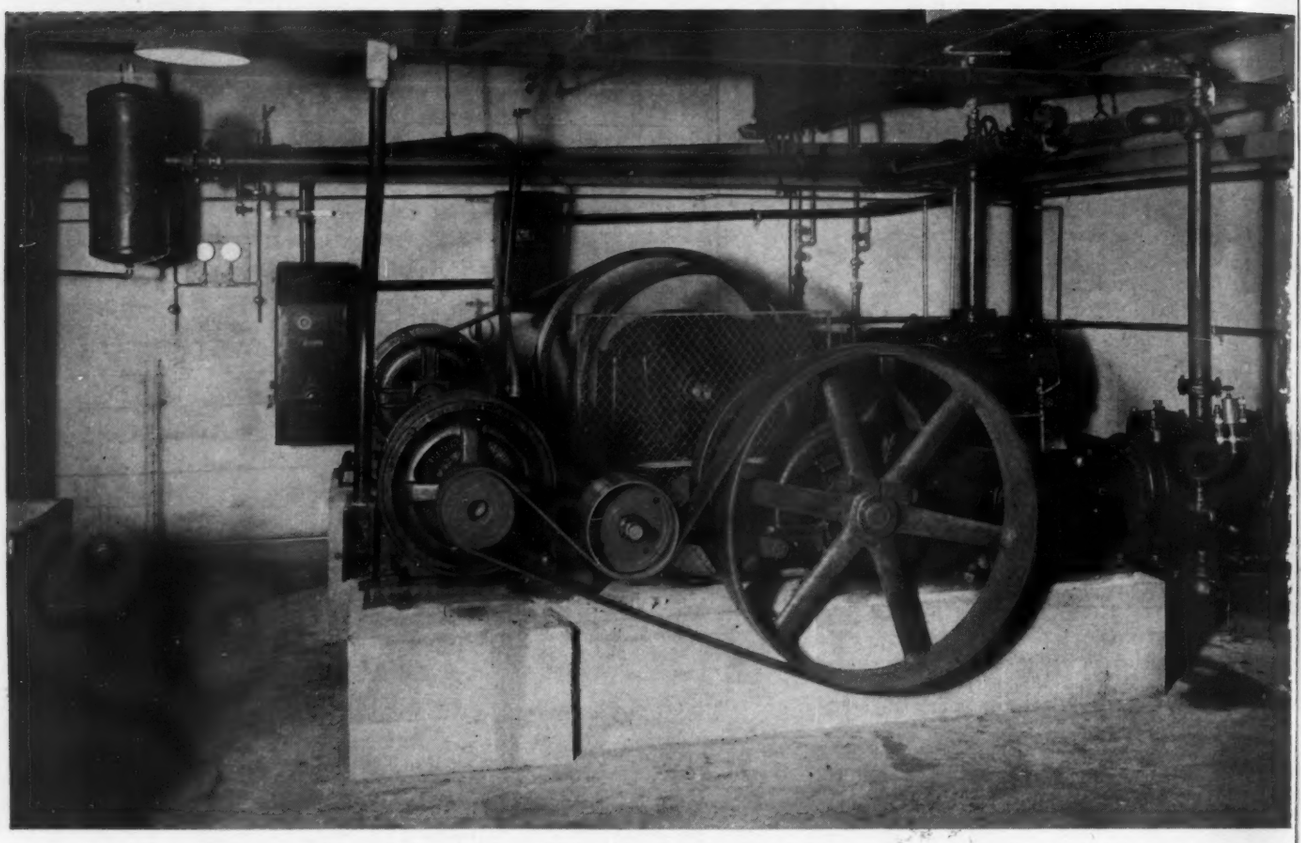






MACHINE OPERATIONS

Literally thousands of operations are required to stamp out the various sheet-steel parts and to give them the necessary form. Most of the primary stamping is done by automatic machines such as that shown at the top. The blanks are then shaped and punched in presses equipped with treadle controls (right). The operator puts each piece in position between the dies; and the finished part, in the case of both presses, is blown from its resting place by compressed air that is introduced through the hose connections and pipes shown. The band saw (left) likewise is provided with an air jet to keep the work clear of metal particles.



COMPRESSOR PLANT

Compressed air performs various important services in the Lionel factory. Nearly all the metal stamping and forming presses are equipped with air jets for lifting finished pieces from the dies. Air is now supplied to six spray painting outfits, and two more are being set up. Compressed air for these and for other purposes is furnished by this plant. The unit in the background—a Class ES-1 that has a piston displacement of 426 cfm.—is used regularly, and the nearer unit serves as a standby. The latter is a Class ER-1 that carried the plant load for a number of years until expanding operations called for a larger machine. To insure the delivery of dry air, it is passed through a Type PL aftercooler—the long, horizontal, flanged pipe above the machines—after leaving the compressors. Near its left end is a separator, where condensed water vapor is extracted before the air goes into the receiver. In another part of the plant a Class ER-2 unit supplies air at 400 pounds pressure for die casting.

trains and associate structures is that they are completely protected against corrosion. Zinc alloy is, of course, inherently rustproof; but all steel parts must be treated prior to assembling them. Of the three methods used for this purpose, the commonest is painting. This is done wherever possible by dipping, otherwise by spraying. Even dipping is mechanized. The pieces are hung on hooks, lowered into a paint reservoir, and carried through a long drying chamber. Spray-painting is done with hand-held DeVilbiss guns, trayfuls of objects being coated in specially designed booths. The trays are then transferred to a moving belt that conveys them through a 50-foot drying tunnel in which air at 185°F. is circulated.

The second form of anticorrosion treatment is chromium-plating. Virtually the entire superstructure of some streamlined trains, as well as numerous parts of standard models, are chromium finished. The work is done by modern equipment, the pieces being lowered first into a cleansing solution and then plated successively with copper, nickel, and chromium. The third method is oxidation, which is effected by immersing the pieces in a caustic solution. All track ties are made rustproof by this method, and thereby given a pleasing dull-black color.

From these various finishing departments, the parts go to the assembly-line feeder belt previously mentioned, and are thence transferred to one of the belts running perpendicular to it. Along the latter sit workers who assemble the pieces into any one of numerous finished products—in all, more than 500.

Meanwhile, in other departments, the essential electrical equipment—including motors, transformers, and rheostats—is being manufactured. This calls for a great amount of winding of fine wires by skilled women workers attending ingenious, high-speed machines. The assembly of motors, locomotive trucks, and interposed driving gears is done by men; and each unit is inspected and tested at the end of the line.

One of the requirements of a business of this sort, if it is to be successful, is adequate facilities for repairing sets already sold. Most Lionel trains are operated by children, and are bound to receive rough treatment that occasionally causes damage. Also, as they really come under the head of machinery, they must, like all mechanical things, be periodically given expert attention. Service stations are now maintained at the company's sales offices in New York, Chicago, San Francisco, and in Toronto, Canada, as well as at its Irvington factory. In addition, plans are underway to establish repair shops in various key cities of the United States. A service station in London handles repairs in the British Isles.

The Lionel management is justifiably proud that its trains appeal not only to amateur railroading enthusiasts but also to many men whose hands know the feel of the throttle of a real locomotive. In addition, the late W. W. Atterbury, former head of the Pennsylvania Railroad Company, was among the list of owners, and Samuel Vauclain, chairman of the board of directors of the Baldwin Locomotive Works is interested in these small-scale systems. Also among the company's customers are such distinguished world figures as Premier Benito Mussolini of Italy, King Leopold of Belgium, King Boris III of Bulgaria, the King of Siam, and the Rajah of Jaunpur.

Die Castings and Compressed Air

Herbert Chase

DIE-CAST ARTICLES

Above is shown a fractional-horsepower air compressor designed for operating a spray gun, together with its component parts which are made by die-casting zinc alloy. At the left are small air-driven tools—a grinder and a filer—in which are die castings of zinc alloy and aluminum alloy. The total weight of the grinder is 1 pound, and that of the filer is 1¾ pounds.

ENGINEERS familiar with the die-casting process are well aware that compressed air plays an important part in making it so highly successful. It is, perhaps, less generally known that die castings are being used to advantage in the construction of very light air compressors, as well as in numerous tools and fittings required for compressed-air systems.

Zinc alloys, because of their excellent physical properties, low cost, and ease of casting, among other reasons, have gained by far the widest recognition in the die-casting field. In the most modern die-casting machines for zinc, the molten metal is nearly always forced into the die by a plunger actuated by compressed air. In some of the earlier machines, the metal was exposed to direct air pressure; but today preference is shown for an air-operated positive plunger partly because it is easy in this way to bring the desired high pressure to bear on the molten metal, generally from 1,400 to 2,000 pounds per square inch. A steel plunger working in a cast-iron cylinder is not subject to rapid wear nor apt to stick upon coming in contact with molten zinc alloy, and is the most satisfactory means for applying high pressure to the metal.

Although it is entirely feasible to die cast zinc alloys in the so-called "goose-neck" machines, with air acting directly on the surface of the molten metal—and many such machines are in successful use, the maximum practicable pressure is about 550 pounds per square inch, and this is lower than it should be to obtain best results, especially in producing castings having thin wall sections. Even in castings having relatively thick sections, the density of the metal increases with higher pressures, and this has a beneficial effect on the physical properties of the castings and, in some cases, gives their surfaces a superior smoothness, thereby improving their appearance and reducing finishing costs.

Whether plunger or goose-neck machines are employed, the die-casting shop is always piped to supply air to each unit. The air usually comes from sizeable compressors, often in duplicate and housed in a separate room convenient to the source of power and located so as to minimize upkeep and maintenance costs. For plunger machines, the air pressure generally ranges from about 60 pounds per square inch upward, and for goose-neck machines from 400 pounds upward.

Naturally, the compressor equipment is selected with due regard to the pressures required; and in plunger die-casting machines the size of the air cylinder used for metal injection is proportioned so that, with the air pressure available, the plunger pressure will come within the desired limits. In all cases, die-casting machines are provided with an interlocking device that prevents pressure from being applied to the molten metal until the dies are closed and locked. This minimizes the chance of workmen being injured by the spattering, molten metal. Besides the supply of air for metal injection, there is usually an outlet for an air nozzle on a line carrying moderate pressure, and this is used as occasion may require to blow out dies between shots and to clear them of any fine chips or of foreign matter which might interfere with the making of perfect castings.

Machines for casting zinc alloys vary in size; and the rate at which air is consumed changes with the size of the castings and with the speed of casting. The largest machines make castings such as automobile grilles and windshield frames, weighing up to 30 pounds and more, at a rate normally approximating a minute per casting cycle or "shot." At the other end of the scale are small machines, some of them well-nigh automatic in operation, that turn out castings of a fraction of an ounce and upward at a rate of fifteen and more shots a minute.

Next in importance to the zinc alloys for die casting are those of aluminum, which have a much higher melting point than the former. Most aluminum die castings are made with goose-neck machines and with direct air pressure on the molten metal because these alloys attack steel and iron and would cause the plunger to stick. Excellent castings are produced; but there is some tendency towards greater porosity than would result with pressures higher

than those practicable by this method. The castings are more expensive than those of zinc alloys and have considerably lower impact strength. For these reasons they are employed chiefly where the light weight of aluminum is desired. Compressor installations have to be such, of course, as to furnish an adequate volume of air at the relatively high pressure required and with reasonable efficiency. Production rates are usually somewhat lower than with zinc alloys.

Although some die castings are made from lead- and tin-base alloys, and a few from magnesium alloys, the total tonnage is comparatively small and the machines and associate air-supply equipment used are similar to those already described in the case of zinc and aluminum alloys. Alloys of copper (brass) and some of aluminum are occasionally die cast in special machines with semimolten metal which is forced into the dies at extremely high pressures, accounting for the name "pressure" castings. But most if not all such machines employ hydraulic rather than air pressure, hence need not be considered here. Compressed air may serve incidentally to blow out dies, however.

From the foregoing it will be seen that compressed air plays an important part in the die-casting process. It now remains for us to take up the second point mentioned in the opening paragraph, namely the use of die castings in compressors and air-operated tools. Here, again, zinc alloys are most prominent. They are superior to gray cast iron in tensile, bending, and impact strength; and the castings can be held within much closer dimensional limits, have a smoother finish, and, in general, call for much less machine work to fit them for assembly. Finishing—plating and enameling—costs are low; and the alloys are nonrusting, though not immune to corrosion in some applications. Production, unless "stock" dies happen to be available, necessitates an investment in dies. However, they are likely to be lower in cost than those for the making of drawn stampings and, once on hand, turn out duplicate parts with great accuracy and at low cost per piece.

Many parts can be die cast which cannot be stamped nor produced so inexpensively by other means. In a large proportion of cases, the saving in machine work is a highly important consideration and may be a factor in choosing die castings in preference to parts made by other methods. Die castings range from the simplest to the most complex designs, and in general are produced so close to size that only the lightest kind of machining such as drilling, reaming, or tapping of holes, or the facing of a flange or a boss, has to be done. Often, even these operations are not required. Assembly with stamped, sand-cast, screw-machine, or other parts is not infrequent, and, in some instances, it is feasible and even advantageous to use such parts as inserts in making die castings.

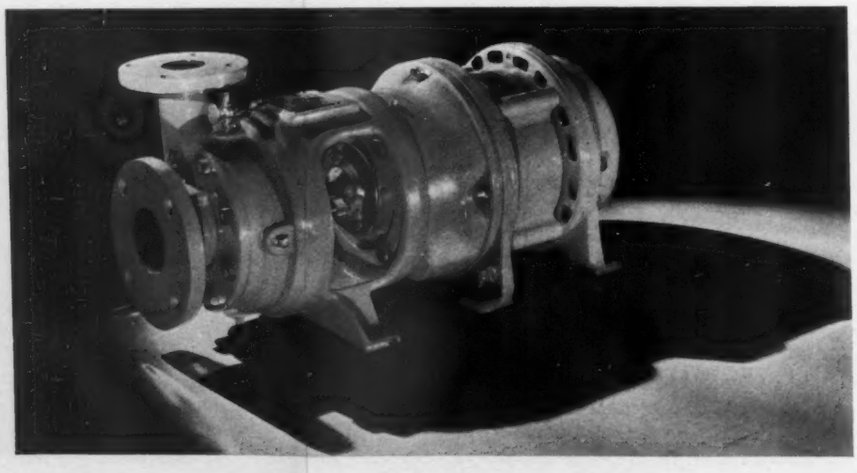
Some of the die castings for small air compressors—chiefly hand-portable machines of the diaphragm type and units for household refrigerators—are exceedingly complex, and have far thinner sections than iron castings produced in sand molds, as well as a smoother surface. Little or no machining is required, and where necessary it is usually of the very simplest kind. Naturally, the cost of die-casting dies has to be taken into account and amortized; but the saving in machine work is generally so great that, unless the total number of parts needed is small, it soon offsets the die cost and for that reason is fully justified.

Not infrequently, die castings can be and are used in making cover plates and similar parts such, for example, as end bells for motors where a stamping might be considered. If any drawing operation is required in addition to the stamping, then the die-casting die is likely to cost much less than the flanking and forming dies for the stamping. Not only that, but the die casting can often be held closer to size and is sometimes easier to finish than the stamped work. Its section thickness may be greater; but wall thicknesses of 0.04 inch or less can be die cast, and it is possible to provide stiffening ribs and fastening bosses, something that cannot be done in the case of stamping.

Die castings are not confined, by any means, to fixed or merely enclosing parts. They are employed, among other things, as pulleys and flywheels having integral fan blades, if desired. Even light connecting rods for small reciprocating units have been die cast—service proving them to have adequate strength.

Portable air-driven tools of moderate size often embody die castings. Grease guns and lubricating devices, as well as spraying equipment, frequently call for several fairly complex parts that lend themselves well to die casting. They would be much more expensive if made in any other way. As light weight is generally a factor in portable units, there are cases where aluminum-alloy die castings are preferable to zinc-alloy castings unless the latter can be produced with considerably thinner sections, which is possible under circumstances because of its much higher impact strength. As tools are apt to be dropped in service, this property of zinc alloy gives it an advantage over most other cast metals available at comparable cost.

In several successful rotary air-driven tools made by the Madison-Kipp Corporation the main frames and certain rotating parts are die cast. The rotors in some of these turn at speeds up to 55,000 rpm. and more, yet the die-cast parts are reported to give excellent service.

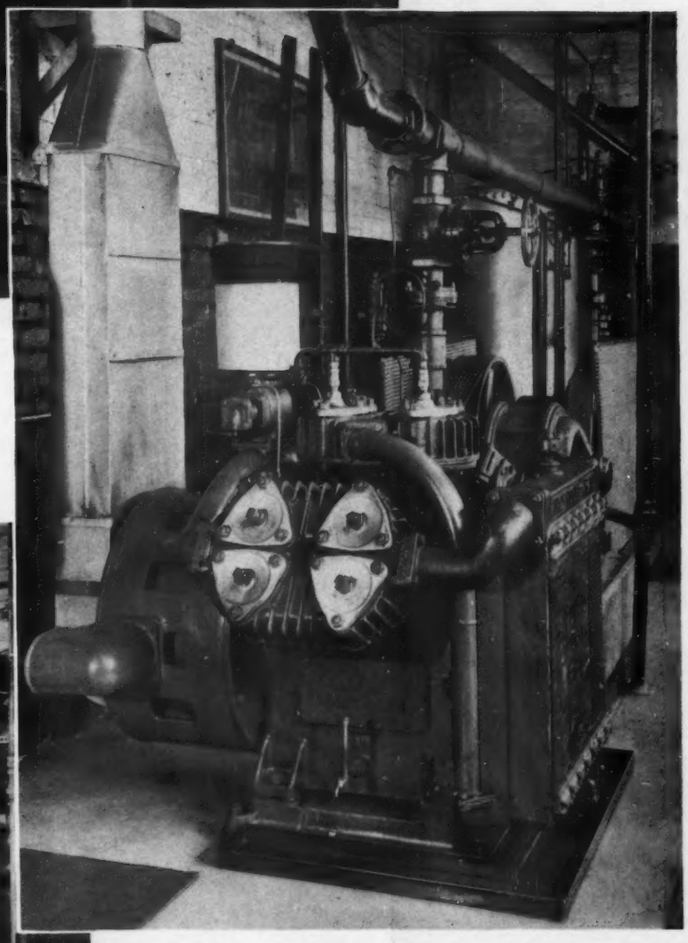


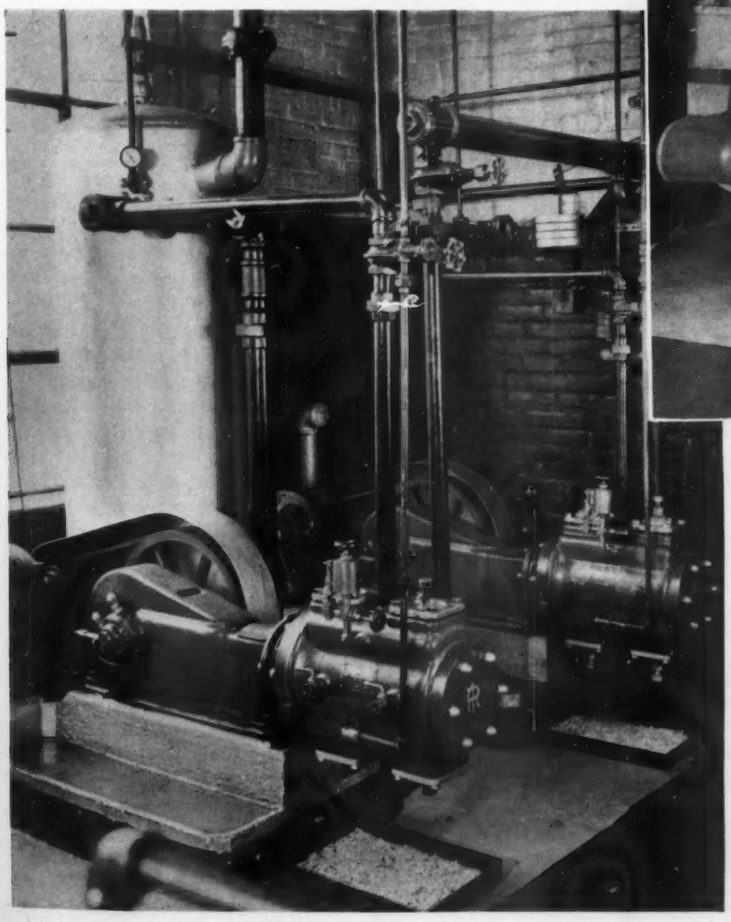
EMBODIES BRONZE DIE CASTINGS

Brass and bronze die castings are often used in machinery when the quantities to be produced are sufficiently large to warrant the expense of the necessary dies. The impeller and some other parts of this Cameron Motorpump are of die-cast bronze.

DIE-CASTING SHOP

A section of the casting room of the Schultz Die Casting Company, Toledo, Ohio. Compressed air is piped to each machine to actuate the plunger that forces the molten zinc alloy into the die.



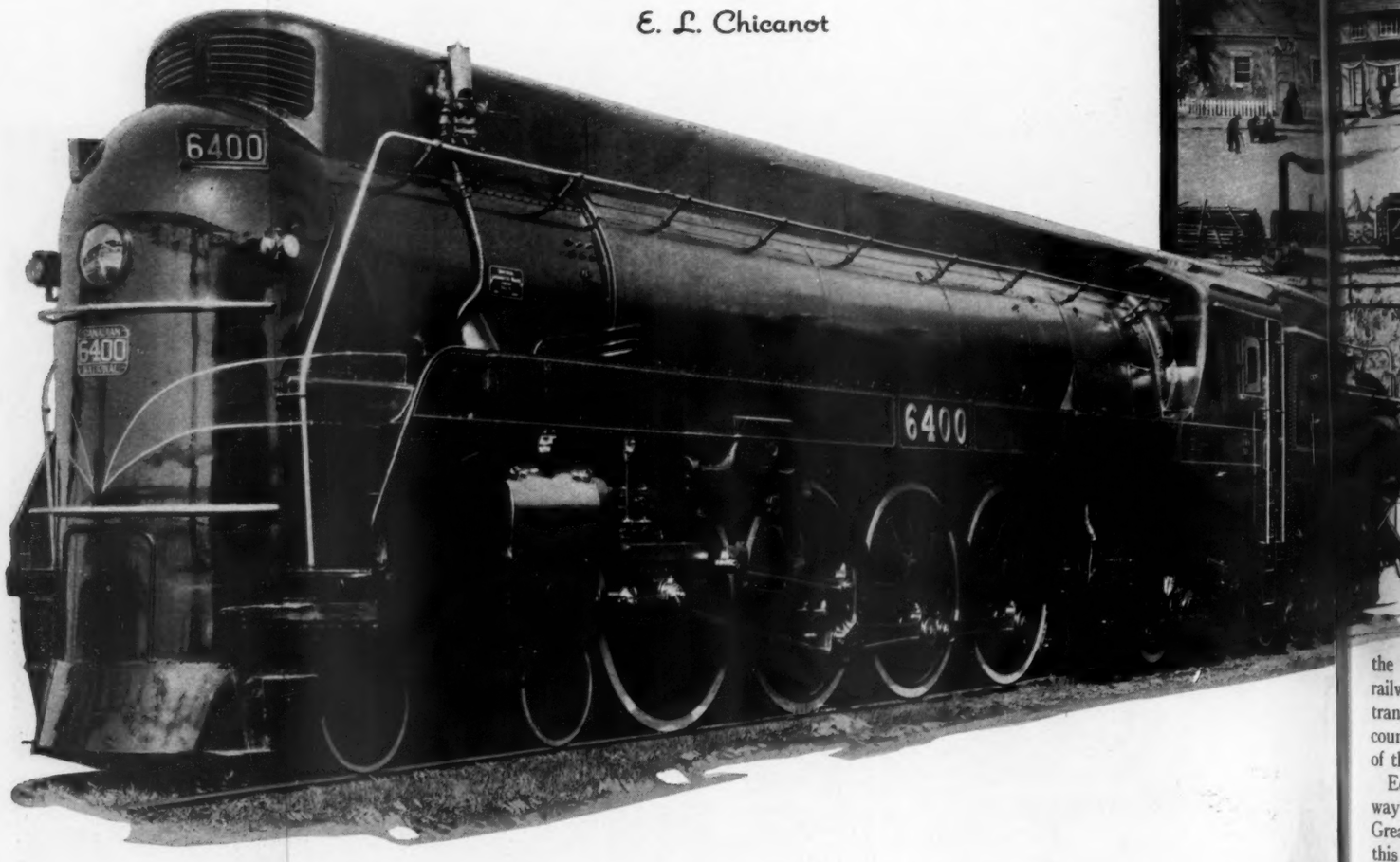


SOURCES OF AIR

These compressors supply air for die-casting operations in the plant of the Schultz Die Casting Company at Toledo, Ohio. The two units at the left are Class ES single-stage machines. The picture above shows a 2-stage, air-cooled Motor Compressor.

Mileposts in Canada's Railway History

E. L. Chicanot



CANADA, in company with the United States, has a serious railroad problem.

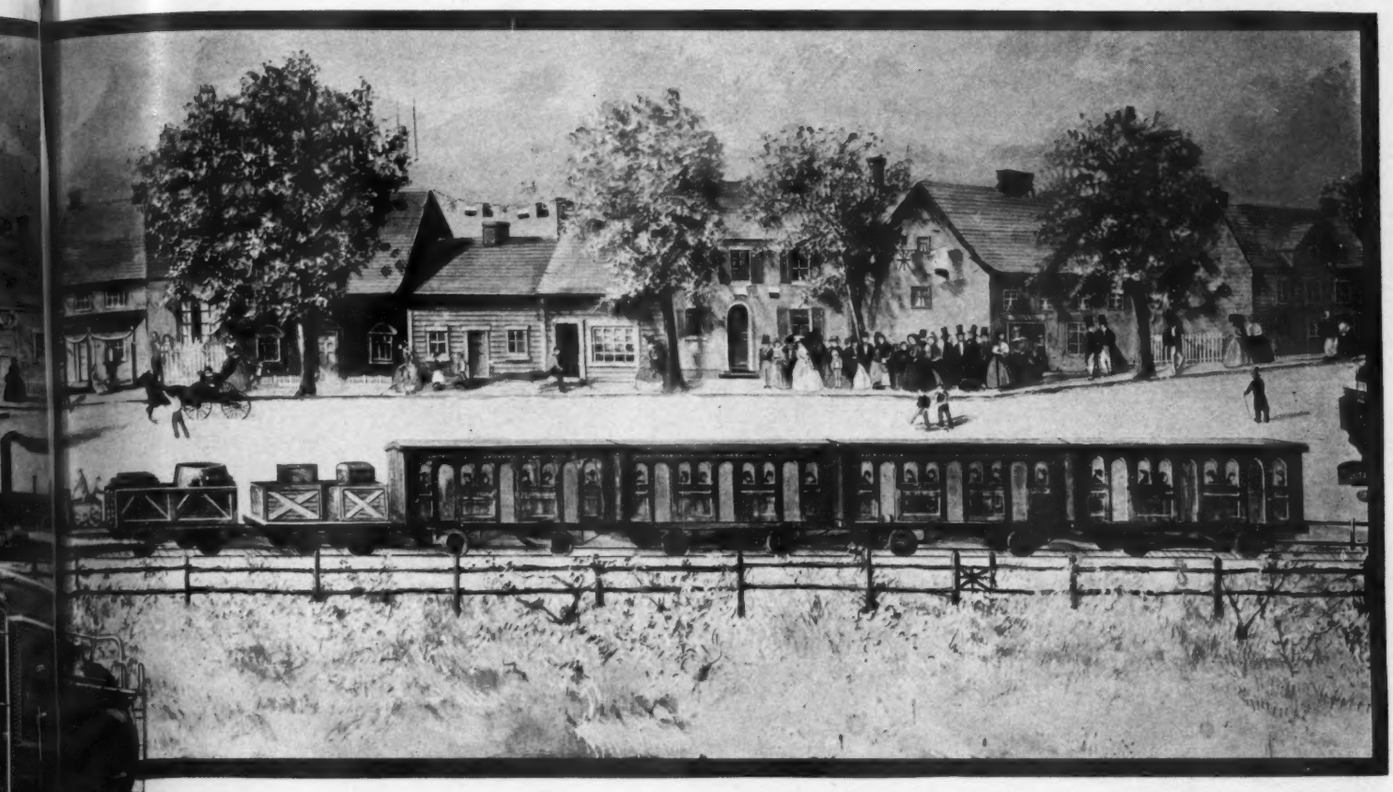
In Canada, it is probably the greatest handicap to complete recovery from the recent economic setback which the country is in other respects successfully surmounting. Nevertheless, one can for the nonce turn one's back on this welter of trouble to record the fact that the year just past was a significant one in Canadian railway history.

It marked the centennial of the opening of the nation's first railroad and also the fiftieth anniversary of the linking of the Atlantic and Pacific by lines of steel. One accordingly feels impelled to rise above the prevailing harassment and to use this vantage point to survey the magnificent accomplishment for which the steam railroad has been responsible in Canada. Such a review, incidentally, will disclose how Canada's railway problem developed.

It is a matter of no little interest to the people of the United States, not only because of the close association of the railroads of the two countries but also because a substantial portion of Canadian railway mileage is actually in the United States. And furthermore, the first stretch of railway built in Canada had for its objective the expediting of the journey between Montreal and New York.

Canada was largely a raw and undeveloped area—a country insignificantly regarded and with no great potentiality disclosed—at the time of the invention of the steam locomotive which was to effect so violent a revolution the world over and to become the main factor in aiding Canada to the attainment of her destiny. In 1835, after the first steam railroad in the world had been in operation just ten years, construction was begun on the first Canadian railway, a line only 16 miles long on the route between the principal centers of the rugged colony and the new, fast-developing republic to the south. A wood-burning locomotive, named *Dorchester*, was ordered from Robert Stevenson & Company in the following year, making the journey from England by sailing vessel. The road was opened for traffic in 1836, a couple of passenger coaches being drawn over the short line of steel to assist in the exchange of travel across the border.

This was the puny beginning from which have developed the great transcontinental systems of the Dominion, with their branches thrusting into productive territory in every direction and continually being added to in the unceasing conquest of the Canadian wilds; giving Canada intimate touch with her neighbor to the south; and taking Canadian commerce to ocean outlets for shipment to the corners of the globe. The first tiny section, with its vigorously puffing miniature locomotive and quaint crude coaches, has expanded to a mileage of approximately 42,000, the greatest per capita of any land in the world with the single exception of Australia. Over this system run the most luxurious and efficient trains. The past century, in Canada as in



THE OLD AND THE NEW

Above is shown the first steam train operated in Canada a century ago. It ran between Laprairie and St. Johns, Quebec. The other picture is of the world's largest streamlined steam locomotive, No. 6400 of the Canadian National Railways.

the United States, has been the era of the railway, and one has only to appreciate the transformation which has come over the country in that period to realize the extent of the railroad's accomplishment.

Economic Canada at the time of the railway's birth scarcely extended beyond the Great Lakes, so that, when the utility of this new transportation agency seemed sufficiently established, the first objective was not unnaturally to link the provinces of upper and lower Canada through their centers of Montreal and Toronto. This was effected with the completion of the Grand Trunk Railway in 1856, the line being extended eastward and westward during the following four years. The next logical development was to make connections with the great centers of the United States. The first of such contacts was achieved when a railway from Portland, Maine, to the Canadian border was leased, thus giving the Grand Trunk a through route 800 miles long from Portland to Sarnia, in Ontario. During the next decade, through the lease of other roads, it established connections with Detroit, Buffalo, and Chicago.

The next step was to link the provinces of the Atlantic Coast with the rest of developed, economic Canada; and to this end the Intercolonial Railway was planned. After numerous vicissitudes, several small stretches between provincial points were constructed in New Brunswick and Nova Scotia. Upon the union of the provinces through confederation in 1867 these were taken over by the Dominion. The federal government undertook the completion of the line from Montreal to Halifax and opened it in 1876. In 1880, with eastern Canada held together by rails of steel, and with contact established at many points in Canada and the United States, there were in all Canada 7,194 miles of railroad. This was just prior to the beginning there of a new era of railway building, that of the transcontinental line.

One of the terms on which British Columbia—the colony which had developed in the extreme west of Canada—insisted if it were to join in forming a united Canada was the construction of a transcontinental railroad connecting Montreal with the Pacific Coast, and it became necessary for the Dominion to undertake this. Building was commenced by the federal government in 1874, work being prosecuted in several places, but no real or satisfactory progress was made. The government became increasingly discouraged, and was finally induced to enter into a contract with a syndicate known as the Canadian Pacific Railway Company.

That company, in return for an agreement to complete the line by 1891, was granted all finished sections and those under construction, a cash subsidy of $25,000,000, a land grant of 25,000,000 acres, free admission to Canada of the necessary building materials, and protection for 25 years against competing lines. Actually, after the writing of one of the most glorious and romantic chapters of Canadian history, which has been the topic of many volumes, the road was completed in 1885, and the Canadian Pacific Railway was launched on that career of growth and expansion which today justifies its claim to being "the world's greatest transportation system."

The inauguration of the transcontinental railway ushered in the most significant era of Canadian economic development, and furnished the factor which was to be mainly responsible for the attainment of the position Canada enjoys today in international regard, with her established and increasing importance in agriculture, industry, and commerce. Penetration of the virgin prairies by the lines of steel resulted in a flow of land hungry that settled on the fertile lands and proved their excellence in wheat-growing—induced a flow of pioneer homemakers from every part of the world that has never entirely dried up and that, by bringing millions of acres under cultivation, has made the western provinces the granary of the empire.

Lines spread in all directions to open new areas to settlement, to take the produce of new farms to markets. The products of growing industrial centers in the east moved in swelling volume to the agricultural re-

A MODERN CANADIAN TRAIN

As regards equipment, roadbed, and operating schedules, Canadian railways compare favorably with the world's best. Here is shown a Canadian Pacific train pulling out of the station at Windsor, Ontario.

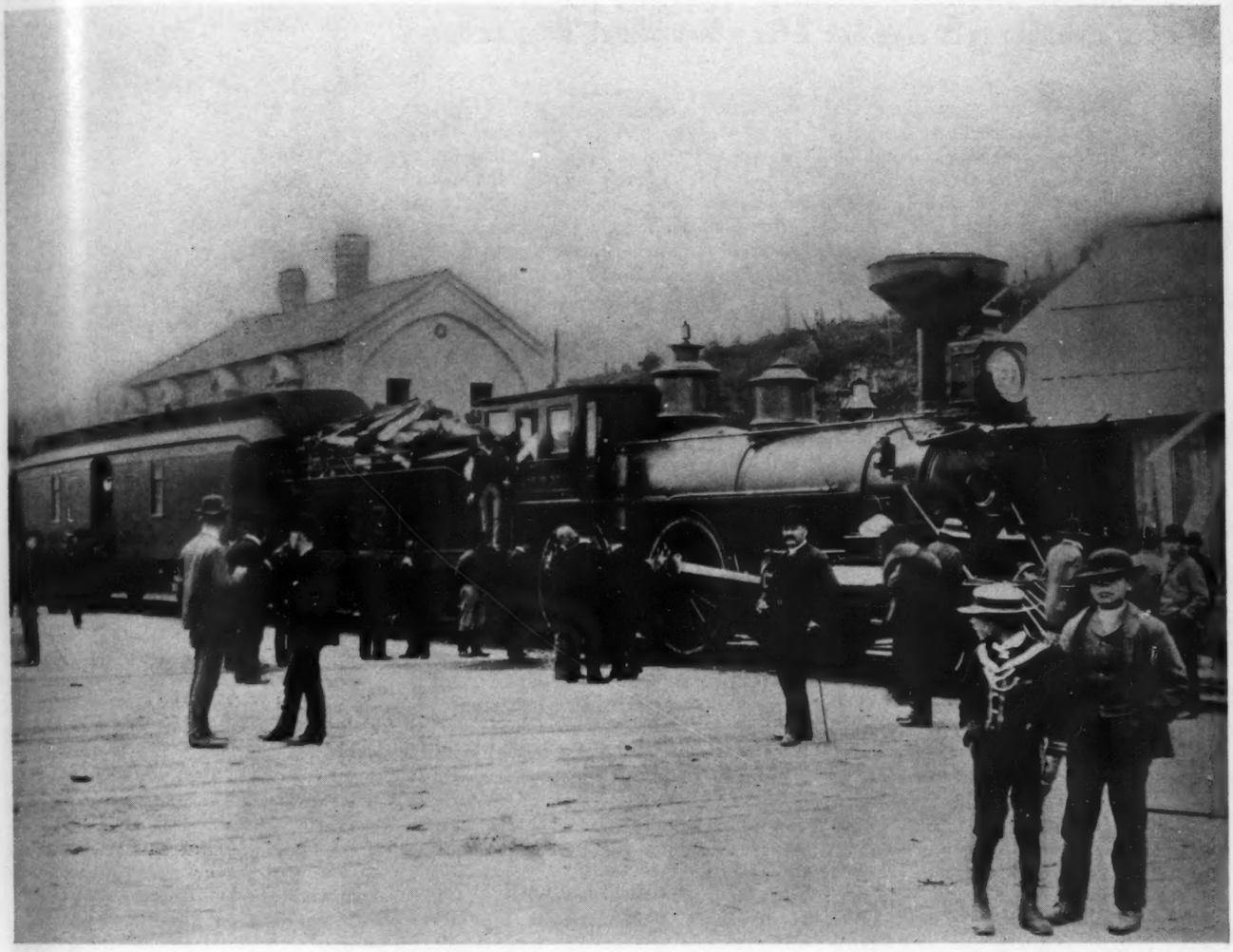
gions of the west; a fleet of vessels was built to convey to the new country people from Europe who had come to envision Canada as a land of hope and new beginning; an ocean service was established on the Pacific to complete an all-red route from Britain to the Orient and the antipodes; resorts were developed and hotels erected as Canadian beauty spots were made accessible and brought to the attention of holiday-makers in other lands. All this came in the wake of the railroad joining the oceans on the east and west. There is no need to dilate on the magnitude or latitude of the Canadian Pacific Railway. It has done more to achieve Canadian economic development, to advertise Canada to the rest of the world, than any other agency.

The success and prosperity of the Canadian Pacific not unnaturally created some envy and aspiration towards emulation, and long before the transcontinental's 25 years of protection against competition had expired, plans were projected with a view to sharing in the growing traffic that followed the opening up of the great agricultural west. The fact that the Canadian Pacific had come within an ace of failure in endeavoring to fulfill its contract seemed forgotten, and only the spectacular success of the enterprise was considered. Canada was developing at an amazing rate, and it was impossible to foresee any slackening in or interruption to this progress. Everyone was optimistic, most of all the government, and it was never doubted that there was room for a second transcontinental railroad which could be made as successful as the first.

At an early stage the Grand Trunk Railway had expressed a desire to share in the settlement of the west, and sought government subsidization for the construction of a line from Sarnia in Ontario to Winnipeg. The result was the Grand Trunk Pacific. The government urged that the railroad be built from as far east as Moncton in New Brunswick through to Prince Rupert on the Pacific Coast; the eastern section to be constructed by the government and leased to the railway and the western section to be built by the railway with heavy government subsidies. Thus Canada's second transcontinental line came into existence.

Canada was still booming, had become intoxicated by the business of railway building, and in her ebullience dreamed of yet a third transcontinental line. This started off innocently enough as a provincial road in Manitoba, expanded under provincial-government encouragement and, in what seems now in retrospect to have been a veritable megalomania affecting Canada, secured guarantees from both Dominion and provincial governments to extend the line westward to Vancouver and eastward to Montreal. Thus the Canadian Northern Railway was born. Between 1900 and 1915 the railroad mileage of the Dominion doubled, increased from 17,657 to 34,882 miles.

Such expansion was, of course, entirely unjustified in the most buoyant expectations of the future, and discounted decades of development even at the rate Canada was advancing. As events turned out, the country was woefully overburdened. Canada had looked for a continued flow of capital and emigration to settle and develop areas



FIRST TO CROSS THE CONTINENT

The arrival at Fort Moody, near Vancouver, B.C., of the first transcontinental train in Canada. The date was July 4, 1888. Note the pile of wood fuel in the tender of the locomotive and the style of hats then worn.

tributary to the new roads and to produce an abundance of lucrative traffic. Instead of this the war intervened, movement of men and money ceased, the cost of operation increased, and the government was finally forced to run the lines and to amalgamate them into the Canadian National Railways.

So, with the end of the World War, opened the most recent era of Canadian railroad history—the era in which the Dominion's railway problem arose. Throughout the postwar period Canada had two great systems, one privately owned and one publicly owned, operating in competition. The former, though seriously stricken by the effects of the depression, is thoroughly solvent, successfully surmounting the difficulties of the times, and promises to continue in unabated fashion its work of national development. The Dominion, when it took over the bankrupt railroads, assumed a huge burden of indebtedness which has grown to the staggering total of almost $3,000,000,000; and the roads keep on piling up deficits at the rate of about $100,000,000 a year. It is the most serious problem facing Canada today in her efforts to get back on a plane of what she regards as normal advancement, one which must in some manner be solved before the ship of state is on an even keel and there is reasonably plain sailing ahead.

But, in the knowledge that she has made mistakes aplenty for which she is now paying the price, Canada is not blinded by this problem and fully appreciates all the railways have accomplished for her in the past. Nor does it obscure her vision and prevent her from realizing all they will continue to do for her in the future. The first lines of steel took scattered, independent colonies in the east and bound them together in preparation for the greater work of confederation—of a united Canada from Atlantic to Pacific—that the transcontinental system was later to make possible. And it has been only through the fact that the Dominion was so created, the vast middle west so opened and developed, that Canada has been able to realize some of her potentiality, with achievements in a dozen directions of such significance and importance as to have elevated her to a position among the great nations.

Probably for no other country the world over has the railway done so much. Canada, a land of tremendous distances, of sparsely settled spaces and widely separated centers of population, could never have attained her present state without the vision, the enterprise, the herculean labors of her railway builders. She would still be largely a raw land of primitive living and elementary production. And because these conditions over her wide expanse change slowly and gradually, the railroad must, in spite of the competition offered by other forms of transportation that have become factors of moment elsewhere, continue to account for the major share of the country's development. At its centennial, the railway in Canada paused only momentarily to glance back as it forged ahead in its work of national aggrandizement.

The photographs used to illustrate this article are reproduced by courtesy of the Canadian Pacific and Canadian National railways.

Preventing Sag in Pavement Patches

ONE OF the latest uses of compressed air is for grouting underneath patches in pavements to compact the backfill and thus to prevent settlement of the patch. The repairing of street surfaces, torn up for the purpose of laying or repairing underground services, has long been a source of trouble to public utilities, water companies, and sewerage departments. In recent years the situation has become more serious. Street departments dislike to have their pavements cut and patched and repatched because the inevitable settlement brings a deluge of complaints from the motoring public about the roughness of the street. Some cities therefore refuse to give the utilities permission to break the surfaces of newly laid pavements for a period of years.

This condition has been brought about by reason of the fact that it has been impossible to pack fill in a trench to its original density. Even with pneumatic tampers to ram the layers of earth in a trench as it is backfilled settlement has been known to occur, varying in extent with the kind of earth and the care taken in tamping. With the removal of the support from beneath a concrete patch it gradually sinks under the pounding of heavy traffic until it reaches a stage where it is necessary to tear it out, ram in another layer of earth, and then put in a new patch. In some cities the street departments insist in doing all the patching, and then charge the utility for it. This, of course, is expensive, and does not relieve the latter of the risk of incurring the ill will of the motoring public or the possibility of damage suits. One utility, for example, was forced to pay a great number of small claims made by pedestrians whose clothes were splashed with water that had collected in such depressions.

In the case of gas companies, this problem has been intensified within the past few years because of the great increase in the use of automatic gas-regulating mechanisms for refrigerators and water heaters which has made it necessary for them to furnish a "drier" gas to customers. Removing of the tars and oils from the gas has caused the yarn caulking in the joints to shrink. So as to stop the resultant leakage in existing lines, each joint has had to be fitted with an iron collar with an external gasket. Thus the companies have been forced to recaulk mile after mile of gas line, which has meant digging a 4x4-foot pit over each joint every 12 feet and making 440 patches for each mile of main so reinforced.

LIGHT AIDS INSPECTION

Frank A. Engel and Dennis J. Manning, superintendent and assistant superintendent of distribution for the Elizabethtown Consolidated Gas Company, of Elizabeth, N. J., were faced with this problem. They decided to solve it by applying a method that has been used for years in consolidating ground and to fill fissures under big dams. Accordingly, a Ransome pneumatic grout mixer and placer was purchased, and the cavity under several patches grouted. The method proved to be such a simple one, and so effectually stopped settlement, that a little more experimenting was done and a procedure developed that is now standard.

The grouting equipment today in service consists of a light truck on which is mounted a 110-cfm. gasoline-engine-driven compressor which supplies air for a hand-held rock drill and for the grout machine. The latter is carried in a 2-wheel frame which is trailed behind the truck. Another truck hauls the sand and cement. Ninety days after a street has been patched, or 120 days if the weather has been very dry, the grouting crew goes over it, drilling a hole 1⅞ inches in diameter in the center of each patch. Into each hole in turn the foreman then lowers an electric light, which draws current from a storage battery, inspecting it to see if grouting is required. For settlement of ½ inch or less no grouting is specified. Generally, about one-third of the patches do not need it.

The Ransome grouter is a cylindrical tank with a conical bottom leading to a nozzle. It is mounted in the trailer frame in such a manner that the nozzle can be lowered into a hole. There is a swivel plate and a rubber gasket around the nozzle so that the weight of the machine keeps the gasket tight against the surface of the street. The grouter has a 3-cubic-foot tank, but generally operates with 2-cubic-foot batches which are made by putting water in the machine and slowly adding the cement and sand. Mixing is done rapidly and thoroughly by agitating the mass. When ready, and with the charging door closed, air pressure is admitted to force the grout through the nozzle. As soon as a cavity has been filled, two men roll the grouter to the next hole and prepare another batch. Two-cubic-foot batches have been found to be about correct for most patches.

The grout is a rather "soupy" mix of one part cement to six parts sand, and is generally applied with air at 15 pounds pressure. As a precautionary measure, Mr. Manning has installed a pressure-regulating valve between the compressor and the grouter. This makes it possible to control the air supply and precludes the use of too much pressure which might raise the patch or waste grout by forcing it under an adjacent slab or down some channel to a sewer.

GROUTING MACHINE

An unusual example of the efficiency and economy of this system was given recently in one of the principal streets of Elizabeth. Fifteen years ago a 20-inch main beneath that thoroughfare was recaulked, necessitating extensive patching of the pavement. Of the thirty 5x5-foot patches then made, one settled and had to be removed; and because of the immense cavity and area involved, the replacement patch was 7x7 feet in extent. An inspection of the remaining patches showed that the backfill had settled away from the slab on an average of 4 inches. It was estimated that to barricade the street, break out the old patches, add more backfill, and make new patches, would cost close to $35 each, or approximately $1,000 for the job. Instead, three men grouted the twenty-nine 5x5-foot patches in half a day's time, and did the work without seriously interfering with traffic.

Where large-size mains pass under wide and expensive pavements it is often much cheaper to tunnel than it is to cut the pavement. However, most street and highway departments forbid this because it is impossible to ram the backfill so that the edges of the tunnel will not settle, permitting the unsupported pavement to crack and break. Mr. Manning has overcome this by drilling holes, 8 feet apart, over the center line of the tunnel. Through these holes, grout is introduced to compact the backfill and to support the pavement.

THE THINGS WE PRINT

FROM time to time we receive requests to publish technical articles dealing with various applications of compressed air or with the operation of air-driven tools or machines. In most instances the writers desire information that will assist them in solving specific problems that confront them. Sometimes we feel warranted in complying: other times we do not. The decision is based on the answer to the question: "Would the subject interest a considerable number of our readers?" Obviously, it would be a mistake to print many articles that would appeal to only a handful of people.

COMPRESSED AIR MAGAZINE is distributed to numerous engineers; but it also goes to just as many, if not more, men in administrative or executive positions. Moreover, our readers, including the engineers, are to be found in every conceivable kind of industry and are scattered the globe over. Technical information concerning, let us say, the selection of a rock drill for a specific gold mine would be of little interest to a city engineer, and of even less to the manager of a gas plant.

We realize that unless we can present material that appeals to the average reader, we are merely feeding wastebaskets and uselessly burdening mail carriers. The companies that print their advertising messages in our pages are keenly aware of the same things. Once in a while we even stray clear away from our field and present an article that has nothing to do with compressed air, not even with mechanical things. And it is our experience that technical men usually enjoy them.

COMPRESSED AIR MAGAZINE is not intended to be a technical magazine. If it were, its appeal, would, necessarily, be greatly restricted. It is true that some material of this nature is presented; but in most cases it is incidental to a story of more general interest.

With this explanation, we hasten to assure those that are in search of purely technical information that we are always glad to assist them in finding it. There are textbooks and reference books that deal with the everyday problems of compressed-air engineering. Data concerning individual tools and machines and their particular application are usually obtainable from the companies that manufacture them.

FLYING HIGH

IT IS APPARENT that future long-distance flying will be done at great altitudes. In a recently published article, J. C. Edgerton, chief of the Stratosphere Section of the U. S. Bureau of Commerce, wrote: "Nothing stands in the way of producing a transport plane capable of satisfactory, sustained flight at 25,000 feet. Such a plane is probably not more than a year away."

As though to make good his prophecy, Pan American Airways announced on February 28 that it would in all likelihood soon award contracts for the construction of several stratosphere-type planes to the Boeing Aircraft Corporation of Seattle, Wash. The craft will be tested with a view to using them in the transatlantic service that Pan American and the British Imperial Airways jointly propose to operate. It is believed that cruising speeds of 260 miles per hour can be obtained at altitudes of 20,000 to 35,000 feet with only half the 5,000 hp. to be developed by the four engines. In addition to the improved performance possible at higher altitudes, safety is greatly increased. There are scattered clouds up to 35,000 feet, but those above 25,000 feet do not cause storms of sufficient intensity to affect aviation materially.

One of the requirements of such planes will be pressure compartments for passengers and crews. The air pressure at 25,000 feet is approximately 5.5 pounds per square inch, as compared with 14.7 pounds at sea level. At 30,000 feet it is around 4.36 pounds. The plan is to compress air and to force it into the plane, thereby maintaining the interior at a pressure close to that at sea level. This calls for compartments capable of withstanding the needful pressures, and of reliable apparatus for compressing the air. It is reported that satisfactory progress towards both ends is being made.

Originally, it was believed that pressure compartments would involve prohibitive weight increases; but recent tests conducted at Wright Field indicate that only about 600 pounds would actually be added to large transport planes. The development of a new laminated glass of great strength has been of material aid in solving the problem. Pan American Airways contemplates building the projected planes so that they will be capable of withstanding an interior pressure of 6 pounds per square inch. Assuming that such a ship flew at a height of 25,000 feet, the passengers could then be furnished with air at 11.5 pounds pressure, which is roughly equivalent to the pressure at an altitude of 6,000 feet and adequate for human comfort and well-being. It has been established that the chemical composition of the atmosphere remains essentially unchanged to heights of probably 60,000 feet, so the necessary oxygen for normal breathing can be obtained by simple compression.

Details of the apparatus that will be used for compressing the air are not yet forthcoming, but indications are that it will be similar in design to the superchargers of the driving engines. As a safety precaution, there will be two such units on each plane. It is believed that it will be feasible to operate them from the exhaust of the engines, although it is reported that one manufacturer has already produced an auxiliary engine-driven machine. According to calculations, 10 cubic feet of air per minute must be provided for each person aboard the plane; and it is very likely that the air will be humidified for the comfort of the passengers and to eliminate fogging of windows. All told, the realm of high flying opens up an interesting field of pneumatic engineering.

Municipality Builds Plant to Service Whole Town With Butane Gas

MOUNT VERNON, Ind., a community with a population of 5,000, is being supplied with butane gas by a municipally owned plant that has been in operation long enough to have established the fact that the fuel is thoroughly satisfactory—the town as a whole, and the housewives in particular, having expressed themselves as pleased both with the quality of the gas and with the service.

It was not so long ago that propane and butane, by-products of the petroleum industry, were wasted. Now these gases, liberated in the course of the manufacture of gasoline, are recovered and sold in liquid form as fuel. In 1935, the latest statistics of the Department of Mines, 34,655,000 gallons of propane were marketed in the United States primarily for household consumption, while of the 34,084,000 gallons of butane distributed during the same period, approximately 27,690,000 gallons were used as industrial fuel, 5,042,000 gallons in the manufacture of gas, and only a small percentage for domestic purposes.

The demand for these gases is on the increase; and on the West Coast, possibly because it is nearer the source of supply, the Spokane United Railways are operating a fleet of 76 buses which have been converted or built to run on butane gas. To service them it has been necessary to provide special stations, and there the gas is stored, ready for delivery, in holders each having a capacity of 12,500 or 25,000 gallons, the last-mentioned being the newest erected.

At the Mount Vernon gas works, the liquid butane arrives in tank cars and is directly transferred to a storage tank which is located about four city blocks from the unloading station. This is done by the unbalanced-pressure method and by means of reserve compressed gas. After a car has been emptied it is, of course, charged with gas, and this is used in the vaporizing system until the pressure in the car has been reduced to a little more than 4 pounds per square inch.

The mixing and generating plant is a modest building of 15x30 feet and houses two compressors—one 830-cfm. machine and one 165-cfm. unit. The latter automatically cuts in when the pressure in the distributing system drops to 8 pounds, building it up again to the 12 pounds normally maintained. Should this compressor prove inadequate in case of unusually heavy demand, the larger machine takes up the load at 6 pounds; and if that is not equal to the requirements, then, with the pressure at 5 pounds, a reserve supply of high-pressure air stored for such an emergency acts as a booster.

The distributing system is 8 miles long and has been designed so that it can be used to carry natural gas, should that become available. It consists of 6-, 4-, 3-, and 2-inch sections, which are laid in the form of loops to prevent dead ends and equipped with valves so that any one of them can be cut off and thus interfere as little as possible with the remainder of the system. There are 1,600 service outlets—about 80 per cent more than the number at present required—which, it is believed, will meet all future demands and obviate the need of again drilling and tapping the main line.

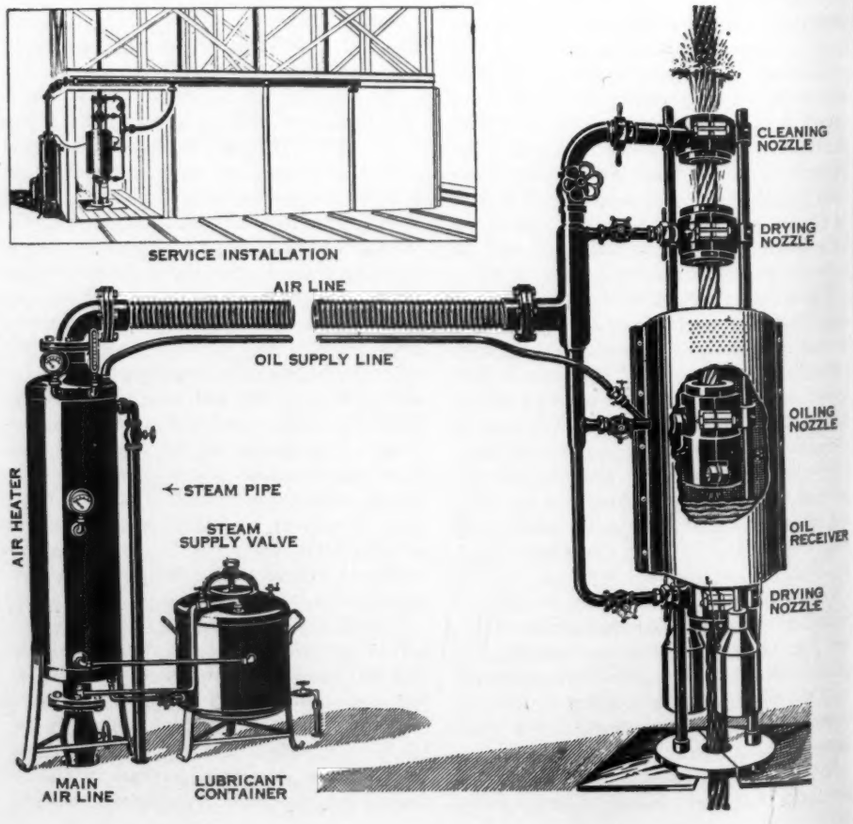
The gas has a heating value of 530 Btu., and is held well within a variation of 5 Btu. by aid of a Thomas recording calorimeter. It is stored in a tank 10 feet in diameter and 42 feet high, with all taps for connecting lines in the top, the same as in the case of the liquid-butane storage tank which measures 8x36 feet. The entire plant, including the distribution system, was built at a cost of $36,309.00.

Pneumatic Cleaner and Oiler for Hoisting Cable

LENGTHENING the life of hoisting cables in mines is the purpose of the Boecher rope cleaner and lubricator, equipment that is being used extensively in Europe and that is now available in the United States. As hoisting cables are vital to transportation—in fact to underground mining operations—it is essential that they be given proper care. This entails oiling and cleaning to reduce wear and tear, work that can be done quickly and satisfactorily, so it is claimed, with the aforementioned apparatus.

The accompanying drawings show the structural features of the equipment as well as a service installation. The working end is in two parts, and can be easily set up around a cable and again removed by manipulating a number of setscrews. As the rope is run down through it, it is first freed of all dirt by blasts of compressed air issuing from a perforated ring. This is followed by another blast of compressed air which dries the cable before it reaches the lubricator. There it is given a bath of grease or lacquer which is evenly distributed by a circular nozzle with compressed air. After emerging from the tank the rope is once more subjected to streams of compressed air to dry it. This completes the operation, which is a continuous one and is performed with a minimum waste of time, material, and power. Both the air and the lubricant are heated before application.

Aside from the fact that the work is done without wear and tear, all the strands, it is said, are thoroughly impregnated, and drying is effected instantaneously regardless of weather conditions. It takes from 25 to 30 minutes to treat a cable 2,500 feet long, and about half an hour both to assemble and to knock down the apparatus. There are more than 200 of the cleaners and oilers in service in mines in Europe.



Industrial Notes

More than 50 per cent of the rubber used in Russia in 1936 was synthetic.

Lufkin, well-known makers of tapes, rules, precision tools, etc., has announced an addition to its regular line of telescoping gauges, bringing the number up to six. The newest model, No. 79AA, has a range of from 5/16 to 1/2 inch.

A fire-resistant cotton duck and the chemical used to make it fireproof are being marketed by Wm. E. Hooper & Sons Company under the name Fire Chief. The liquid comes in cans or drums ready for application by brush or air spray. Awnings, covers for boats, machinery, etc., made of the chemically treated fabric are also proof against water and mildew.

Japan is soon to start work upon what is claimed will be the world's second largest dam. It will be built about 55 miles distant from Tokyo and will serve to impound water sufficient for the needs of 8,000,000 people. The estimated cost of the project is $11,515,000, and it will take seven years to complete.

Mineral Yearbook 1936, the U. S. Bureau of Mines' annual review of the industry in the United States and abroad, is available for distribution and may be obtained through the bureau in Washington, D. C. In addition to a wealth of statistics on both minerals and mineral products, it deals comprehensively with the economic developments and trends of the mining industry.

Admos is a new bearing metal that contains 70 to 80 per cent copper, 20 to 30 per cent lead, small percentages of other metals, but no tin. Bearings faced with the bronze alloy, which is of foreign make, are said to withstand continuous operation under a pressure of 2,750 pounds per square inch at a circumferential speed of about 60 feet per second.

Plywood conduits, according to a British manufacturer, are better suited for large air-conditioning installations than are sheet-metal ones. In experimenting with the material, it was found to be more durable in some cases; and it also permits the making of piping that is 95 per cent airtight even when corners and obstructions necessitate numerous bends in the line.

Where lifting magnets are in use, the following experience of the maintenance department of a large steel mill may prove of value. That department, simply by improving the method of impregnating the coils, has cut the upkeep cost of the magnets in half. The work is now done by a vacuum-pressure system much like that employed in creosoting timber. The reinsulated and green coils are mounted in a case that is provided with connections for a vacuum pump, a tank containing the preservative, and an air line. The case is put in an oven and heated for 48 hours, after which it is evacuated together with the coils and filled with the impregnating compound, which is hot. When fully charged, compressed air at a pressure of from 80 to 100 pounds is applied to the free surface of the fluid, forcing it deeply into the coils and thus thoroughly impregnating them.

At the highly mechanized foundry of the Kelsey-Hayes Wheel Company, Detroit, Mich., pneumatic rams push the poured molds from the plant's extensive conveyor system on to the vibrating screens at the shakeout station. The foundry was built at a cost of $1,000,000, and was recently placed in operation.

Something new in paint brushes has been developed in England. It is a substitute for the familar spray gun and, like the latter, depends on compressed air for its operation. The paint is fed from a pressure tank to the center of the brush, and from there evenly and uniformly distributed to the bristles. Full details about the brush are lacking; but it is said to do its work without waste and without creating objectional fumes.

TRUCK-GREASING PIT

This outdoor grease pit is 60 feet long and is capable of servicing the largest truck and trailer without having to move either during the operations. Three sets of hose equipment are provided, each connected with pipe lines through which the grease is brought into the pit under pressure. An attendant is on duty 24 hours a day, a floodlight being available for night work. The pit is a part of a truck service station maintained by the Associated Oil Company at Sacramento, Calif., which is on several highways of heavy truck travel.

Where compressed air at a uniform pressure of 30 pounds or less is required, the new De Vilbiss regulator may find application, though it was designed primarily for use in connection with paint-spray equipment. The essential feature is a rubber diaphragm, 4 inches in diameter, which is clamped in the regulator between two brass castings. The device is said to be positive in its action, and to assure a continuous supply of air that will not vary more than 1 ounce for every 10 pounds delivered.

With Protect-A-Wall there is no excuse now for not keeping painted, varnished, or enameled interior surfaces clean, so the manufacturer of the new material tells us. It is a powder that, when dissolved in water and applied to walls, covers them with a film that prevents grease, dust, smoke, etc., from penetrating and marring the finish. Surfaces so treated can be washed with plain water when dirty, and then given another application of Protect-A-Wall. The solution is colorless, transparent, and free from acids and alkalies.

Within a span of 30 years, the annual tire bill of the average automobile owner has dropped from around $220 to $15. At least, that is what statistics gathered by The B.F. Goodrich Company, Akron, Ohio, have revealed. In 1907, a car had to have not less than five new tires a year if it was to be kept in running order, and at that time a tire and tube, good for only about 3,000 miles, cost in the neighborhood of $44. In 1937, according to this company's estimates, it will need only 1.3 tires. So much for what research and development have done for the motorist.

For tinplating small metal parts, Circo Products Company has devised a machine that embodies a new bath and a power unit termed the Powr-Pak. Instead of the usual motor and generator, alternating current at 110 volts, 50 or 60 cycles, is taken from the regular service line and passed through the Powr-Pak, which transforms it to that required for the plating bath. Tin anodes are dispensed with; and the machine operates continuously with solutions at 150°F. It is large enough to accommodate one set of standard automobile pistons, their size determining the length of time needed to do the work. Six Chevrolet pistons, for example, can be plated in 45 minutes, while the general rate of deposition is approximately 0.001 inch per hour.

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PLUS VALUE NO. 1

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